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ON THE ANALYSIS OF THE MEMORY CONSCIOUSNESS FOR PICTURES OF FAMILIAR OBJECTS.[1]

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A. INTRODUCTORY.

1. *The Problem and Aim of the Study.* The present study is a continuation of a program begun in one previously re-

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ported.[1] A few studies made by other investigators on the analysis of the memory consciousness were there briefly noted. In another place an attempt was made to outline what seemed to me the central problems in the general field of memory analysis.[2] For the present purpose it will be sufficient to recall a few of the more general questions in memory analysis with which the present study is chiefly concerned. Relatively speaking, nearly all previous memory studies have dealt with the quantitative aspect of memory, and a much smaller number with the determination of the types of mental imagery. The analysis of the memory consciousness is not at all concerned directly with the former of these problems, and the latter is only a very small part of its general aim. This general aim is threefold. First, the analysis of the memory consciousness into its elements. What different kinds of mental imagery, what organic sensations, and affective states occur in the mind from the beginning to the end of the process of the recall of a given thing? Secondly, the determination of the function in the memory consciousness of each of these elements. What is the order in which they appear, of what use is each in attaining the end that is desired, to wit, the reinstatement of the imagery that is wanted and the recognition of this imagery as correct or not? Thirdly, since the end product of a recall process is often a memory illusion, a prominent question in memory analysis is that of the nature and causes of these memory illusions. In the actual investigation of memory these are not independent general problems; for any study that is aimed mainly at any one of them will yield, and needs, considerable data with regard to the others, the second necessarily presupposing results on the first.

The results of studies of mental imagery hardly answer any part of these general questions directly. In our usual thinking we are not given free choice as to what sort of imagery we shall use in recalling things, because the occasion so often demands that we recall how a thing looks, or sounds, or tastes, etc. Thus, for example, to know that when one is given that choice one's imagery will be visual in 50% of the cases, auditory in 30%, motor and tactual in 15%, will not tell us much about the nature of the memory content in the total process of the recall of any one given aspect of a thing. Furthermore, the mental imagery studies do not tell us anything about the *function* of the different elements (different kinds of imagery),

[1] On the Analysis of the Memory Consciousness: A Study in the Mental Imagery and Memory of Meaningless Visual Forms. Psy. Rev., 1906.

[2] Problems in the Analysis of the Memory Consciousness. Jour. Philos., Psy., and Sci. Meth., 1906.

that enter such a process of recall. If I am trying to recall the nature of sounds I have heard I must recall auditory imagery, but it is not likely that my recall process will be made up entirely of a succession of auditory images. It will include most likely visual imagery of the things that produced the sounds, verbal imagery of their names or verbal description of some of their characteristics. It might include tactual, gustatory, and other imagery in addition. This secondary, non-auditory imagery which does enter may serve some purpose in the total memory consciousness, or it may not. In this given case of the memory consciousness for sounds, therefore, our double question of analysis into elements and determination of function would consist of determining what secondary imagery does enter, and what part it plays in the reinstatement of the auditory imagery and in the recognition of its correctness.

There are certain conditions which we know beforehand will determine in part both the kind of secondary imagery that will enter a recall process and its function. The first of these is the sense department in which the perceptive experience is given. A second is the degree of complexity and the familiarity of the material to be recalled. A third is the time interval since the original perceptive experience and the frequency of intermediate recalls. A good many others might be added, but these are the main ones. In the previous study referred to above meaningless visual forms were used, a group of which the subject committed to memory and recalled several times with detailed introspection and with increasing time intervals between the successive recalls. In the present study pictures of familiar objects were chosen because they present, as regards associated meaning and familiarity, a wide contrast to meaningless forms. The two classes of material together cover fairly well the range of differences in this respect.

In the present study, as in the previous one, the question of the function of the secondary and other associated imagery that entered the recall process was kept in the foreground, but the pictures of familiar objects offered the possibility of more and greater variety of imagery than was the case with the meaningless forms. The objects represented in the pictures, as may be seen in the cuts given below, were such as might appeal to all the special senses. Thus in the recall of some there was given the possibility, at least, of verbal, auditory, tactual, motor, gustatory, and olfactory imagery of the things represented; and this might appear in the recall process either before or after the visual image had been reinstated. But it may be stated at once that as a matter of fact auditory imagery entered only a few times, and then only in the case of one subject, and tactual, gustatory, and olfactory imagery

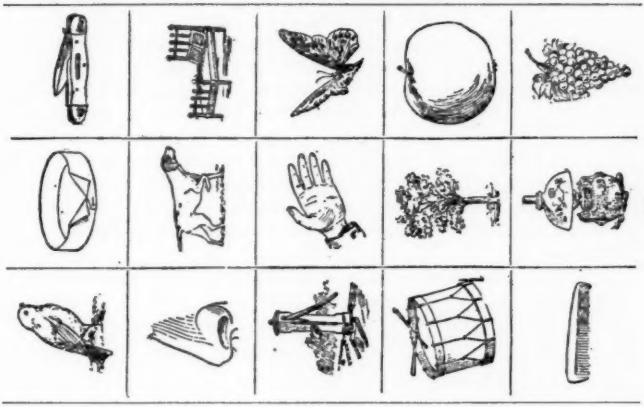
never entered at all. This, then, is so far a characteristic of the recall of the visual aspect of things. In the analysis of the recall process as such we shall be concerned alone with the detailed description of the nature and function of other associated visual, verbal, and motor imagery, and shall consider how these were influenced by the lapse of time and the repetition of recall. To this will be devoted section C of the outline: "The Subjects' Methods of Recalling a Picture as a Whole." After the recall of the visual image of the picture as a whole has been considered, we shall proceed to the description of the recall of its further details. Here I shall take up especially what I have called the "criteria of correctness," which, as will be seen, was an essential factor in the process of recall, as well as in the recognitive consciousness, using this last term in a wide sense. The complete visual imagery of a picture as finally recalled was often wrong. These inaccuracies will be taken up in the section on "Changes in the content of the imagery," and their causes discussed.

2. *Method of Study and Procedure.* Two groups of pictures were used, and five subjects participated in the experiment.[1] The cuts show, on a slightly reduced scale, the character and the arrangement of the pictures in the groups. They were in black and white and the square spaces for the individual pictures were square inches.

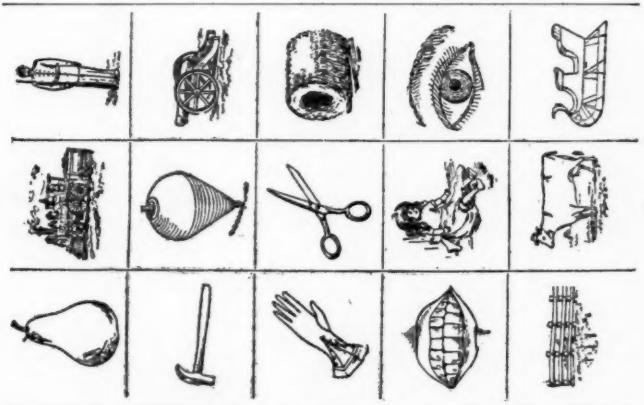
In making the experiment a group was placed before one of the subjects at reading distance and he was given from six to twelve minutes in which to commit it to memory. He was told beforehand what the later procedure in the experiment would be, and that he should attend to the details in the pictures as much as possible in the time allowed. During the six to twelve minutes he was told when half his time had passed, and again when only one minute was left. The subject did not, after this, see the pictures again at any time. Immediately after memorizing a group the first introspective recall was required. The method of study and analysis was entirely that of introspective observation. In this immediate introspective recall the subject was first asked to describe in detail how he went about memorizing the group, and then to recall the individual pictures, one at a time, giving the order and nature of the imagery for each, the presence, character and use of associations, etc. This process, except the questions on how the pictures were memorized, was repeated three times after this with increasing time intervals, several days inter-

[1] As in the former study, the writer was the subject in a few weeks of preliminaries to determine minor matters of procedure, and was also one of the subjects in the regular experiment later.

vening between the immediate and the second recall, about ten days between the second and third, and about four weeks between the third and fourth.[1] In all but the immediate recall the procedure was divided into the two following parts: The



II.



I.

subject was first asked to recall the group as a whole, naming the pictures, but not stopping to recall any details, letting the

[1] These intervals varied somewhat, as a rigid adherence to uniformity would have involved great inconvenience to the subjects. But nothing in the experiment required greater uniformity than was secured.

recall take its own, passive course. When introspection on this was completed, which required giving the order and nature of the imagery, and the use made of it, for each picture, he was asked, secondly, to recall each picture in as much detail and as well as possible and to give his observations as before. In this part one picture was taken at a time.

The whole procedure was carried through with the two groups of pictures and five subjects, excepting that two of the subjects had only one group of pictures each, and for the last two subjects the upper three pictures in the first group, and the lower three in the second group were removed, and the time for memorizing them was shortened.[1] The aim was to allow for the memorizing just sufficient time to insure ready recall of all the picture at the first sitting. Usually then some would be entirely forgotten by the second or third sitting.

B. Subjects' Methods of Learning the Material.

How one will recall what he has memorized depends necessarily in the first place on how he has gone about committing the things to memory. The kinds of associations and secondary imagery he will use in recall will depend on the kinds made use of in learning the material. An analysis of the latter will therefore always throw some light on what occurs in the recall process. One's method of memorizing any given material will depend again on a number of conditions, the more prominent among them being the nature of the material, and the manner in which it is presented. Generalizations on this point cannot be made *a priori*, but a few general suggestions from analyses already made will help to give more meaning to the following description of what occurred in the subject's mind while memorizing the group of pictures, in other words, to his methods of learning the material.

If material for memorizing is presented to one sense, the subject has always the choice of using or of not using mental imagery from other senses, motor processes, and verbal descriptions in committing that material to memory. If we call these latter *aids* in memorizing, he may, further, give more attention to the aids than directly to the sense field in which the material is presented. If the material is visual, he may, for example, give more attention to learning the names and to verbal description, or some other aid, than to the visual aspect of the things presented and to visual imagery. From studies previously made it can be said safely that the subject will use

[1] The number in a group was determined simply by the time required for the introspective recall. A group of fifteen made a sitting of an hour and a half, which was found too fatiguing.

quite different aids, and use them in different ways, according as the material is visual, auditory, olfactory, etc. Similar statements can be made in regard to the dependence of the methods of learning on the complexity and familiarity of the material, in whatever sense department it is presented. Also, the way of presenting the material will determine in part the procedure of the subject. If the different things in a group or list are presented simultaneously, he will do differently from what he will do when they are presented successively. Simultaneous presentation favors the use of associations among the objects presented, and will also make the subject voluntarily divide his time between perception of material and trial recall. A good many other matters of this sort might be mentioned. But this is not necessary, if it is clear that an exact analysis of all that the subject does while memorizing the material, when all the conditions are taken into account, should be made and kept in mind in order to help the understanding of many things about the recall process. Some matters about the methods of learning are quite naturally so general as to be independent of the particular subject and of many of the alterable conditions of the experiment. Others are entirely dependent on some minor point in the procedure. The following analysis of the subjects' methods of learning the material includes all the details that were definitely established in the present series of experiments.

Without an exception, the subjects learned the pictures in order from left to right in the horizontal rows, and the rows from the top downwards. The regular arrangement of the pictures eliminated almost entirely any effort to commit to memory the positions of the individual pictures in the group. This took care of itself. It contributed further to the ease of memorizing by readily permitting associative grouping, and by fixing at once a definite order of procedure. Also without any exception, the subjects alternated learning with trial recalls several times during the six to twelve minutes allowed for memorizing. To determine in this way what could already be recalled and what needed further special attention usually took nearly half of the total time. While looking at the pictures the attention was always predominantly directed towards the visual, visually noting what the pictures were. Simultaneously naming them, and to a much less extent, describing details, might then incipiently accompany the visual process, or the subject might voluntarily attempt to keep in mind the names as he proceeded. In either case, the attention went first to the names in the trial recalls. With only one exception (one subject for one group of pictures) the effort in the trial recalls was to get first of all a series of names. Whether or

not he would visualize the pictures at all when going over this series depended on the subject. The reason for this attempt to get a series of names was variously given. It was for the sake of preventing forgetting any of them altogether, or because it was easier to recall the names than to visualize the pictures successively, or for the sake of fixing the order of the pictures. The first seems to have been the main one. The ability to recall all of them in some form was first sought for. Only after this could be done would attention be paid to the details of the individual pictures.

Noting visually what the pictures are and their details is properly regarded as the direct method of making certain the recall of their visual images. The aids to this direct process were then, first, the names that were always associated with the pictures. Verbal description of the details, which was a quite common aid with the meaningless forms, occurred so rarely with the familiar pictures that it may be left out of consideration. Secondly, associations between picture and picture (depending more on the subject than on the nature of the pictures) were frequently aids in memorizing the latter so that none would be forgotten as wholes. Associations were much less sought for than was the case with the meaningless forms; were much more easily obtained, coming in usually of themselves and in unexpected ways; and were of a larger variety, most of them being of a different nature from those used in the memory of meaningless forms. Taking a distinctly psychological, rather than a logical point of view, they fall into a number of classes: (1) A mere felt connection between two or more pictures. The subject would not be able to report in what way they were connected, or anything further about the nature of the association beyond the statement of the presence of this emotional reaction aroused by regarding the pictures in question. (2) Putting several together into one class, describing them by one adjective or phrase. Accompanying this classifying was an emotional reaction of the same general nature as above. In just a few cases there was introduced in addition an extra visual image that in some way represented the class. For example, *glove*, *scissors*, and *muff* were associated with 'millinery,' and a millinery store was visualized. *Teeth*, *child*, and *eye* were associated with 'things pertaining to human beings,' and a person visualized. (3) Putting several together as parts of one complex scene. In this a visual image of a complex scene was used in which the things represented by the several pictures associated were present as parts. Thus, *fence*, and *cow* were associated by a visual image of a cow in a pen, of a cow fenced in. *Pump*, *hand*, and *butterfly* were associated by the visual image of the subject pumping at a hand-

pump with a butterfly sitting on the ground nearby. In this class a verbal descriptive phrase might, or might not, accompany the visual scene. (4) Combining the names of the pictures into a phrase or a sentence. *Nose*, *dog*, and *bed* were combined into "The dog knows his bed." *Teeth*, *child*, and *eye* were combined into "Idol's teeth," regarding the child as a doll for this purpose. (5) With any individual picture various associative suggestions might occur without in any way connecting that picture with another. Excluding the names of things in the pictures, such associations with individual pictures were much more loosely connected with the images of the pictures than were the others. They, as a rule, did not seem to be an integral part of the total complex involved in the recall of the visual image of a picture and were regarded by the subject as "mere suggestions."

C. Subjects' Methods of Recalling a Picture as a Whole.

In this section will be considered the nature of the mental content in the process of recall, and its function in that process, when an attempt is made merely to recall the pictures as wholes, not stopping to recall any details of the visual imagery of the pictures. A consideration of the changes dependent on the lapse of time and the repetition of recall will also be included. We shall be concerned entirely with the aids to recall, for the kinds of aids that the subject uses and the way in which he uses them constitute his method of recall for the given conditions. In case of the immediate recall, the recall process was in a very general way a repetition of what occurred in the mind of the subject while looking at the group of pictures and during the trial recalls while memorizing them; the same kinds of imagery, the same aids, reappeared in the immediate recall in about the same way. But even in this immediate recall there were some significant changes both by way of omissions and of additions, while in the later recalls the whole process was often quite different in content, and in the function of the elements in that content, from the original learning process. The analysis of that part of the recall process that will concern us in this section will have to do with the following: (1) Some factors determining the order of recall; (2) the associations; (3) verbal imagery; (4) certain visual antecedents, that were not visual imagery of the picture itself. The term 'associations' is used here in a restricted sense. Only the mental content that was classed under "associations" above, and which was divided into five different kinds of associations, will be considered under this heading. The nature of the results makes this method more convenient than the

strictly logical one which would place nearly all the means of recall under the heading of associations.

1. *Some Factors Determining the Order of Recall.* As already stated, at each sitting, excepting the first one for a group, the subject was asked first of all to recall all the pictures while remaining in a semi-passive mood, letting the recall take its own course. He was requested to use a special effort only in inhibiting the recall of details of any one picture, if such a tendency should appear. The object of this was to determine the general mechanism of recall, as it would appear in the differences in the spontaneity of the imagery for different pictures, in the different classes of imagery for any picture, and in the presence and use made of associations. With this procedure, the order in which the pictures were recalled becomes significant. It shows some of the factors that are at work, and something about their relative efficiency in producing again the visual images of the pictures.

The general fact in regard to the order of recall was that at the first sitting the pictures were always recalled in the definite order in which they had been learned, from left to right and from the top downwards. At the second recall this order was already considerably broken up. At the third and fourth recalls it was changed still more, so that in individual cases little or nothing of the original order could be detected. Arranged in a table of distribution, all the cases taken together show only a general tendency to recall the pictures in the order in which they were learned, the rule being that any individual picture was more often than not recalled out of its exact order, but in the majority of cases not much out of its order. A minor tendency to recall them in the reverse order is then also detectable.

The order of learning was evidently, in the first place, determined in part by the reading habit. Also, in the recall there was sometimes present a general visual image of the rectangular group of squares in which the pictures were placed. With the presence of such a visual image the reading habit would incline the recall to take the order of the learning. This, because of the thoroughness with which the reading habit is fixed, must have been a more or less constant factor. The order of recall was then, in the second place, fixed, of course, through the working of the principle of contiguity. This was possible in two more or less independent ways. First, in giving a definite sequence of visual images, and secondly, in giving the same sequence in the series of names. Against these factors the influence of others finally broke up the original order of recall. The nature of the results as a whole makes it rather evident that this was due more to a recession of the former

than to an increase in the inherent influence of the antagonizing factors. Of these latter several can be made out with certainty. (1) There was a difference in the inherent spontaneity of the imagery for the different individual pictures. Aside from associative connections, of special interest, of position, or of any other factor that could be detected by introspection, the images of some pictures came up more readily than others and tended to come up before others. (2) An association, apparently from a variety of different causes, might have a special prominence, be recalled first, and with it the pictures it involved. In a good share of instances the subject consciously sought for the associations when the visual image of none of the pictures rose at once directly. Again, in a number of instances the association was related to some personal experience of the subject, giving it a special spontaneity. (3) A general visual image of the positions of the different pictures, which was much aided by the regular arrangement of the squares, in the majority of cases preceded the recall of individual pictures. When for any reason a picture was recalled out of its order, there was a very strong tendency to recall next the one next to it. In this tendency, however, when the original order had once been broken, the one that followed the picture in question in the original order was shown no noticeable preference over others next to it. There seemed to be a tendency to get back to the proper starting place, an expression, undoubtedly, of the tendency to follow the reading habit which was made possible by the presence of this general visual image of positions, but which, in this case, broke the original order still more instead of helping to preserve it. The objective results and the subjects' introspections agree in making this general visual image of the arrangement and positions of the pictures a considerable factor in determining the order of recall. By inference, it would seem that this factor probably also accounts for the slight tendency to recall the group as a whole in the reverse order.

2. *The Associations.* (a) Their Uses. Twenty-four cases of associative connections that were made among the pictures while committing them to memory were of such a nature that the history of each could be traced through the four successive recalls. In the present description the figures that are given are based on these cases only.

The function of the associations needs to be considered only in the actual recall of the pictures, and it is assumed that when the subject was conscious of the association *before* the visual image or name of the picture appeared, the association then assisted in the recall. It might, of course, appear after the recall, and then add to the recognitive certainty as to the cor-

rectness of the recall; but it added to recognitive certainty so rarely, occurring only a few times, that it may be left out of account here. The subject did not seem to need this aid to the recognitive process; he was certain that the picture recalled was one of the group without it. In this respect the function of the associations was here essentially different from that in the memory of meaningless forms. The subject's general attitude in regard to their use in the recall was also different. As was the case in learning the group, so in the recall later the associations were much less sought for, were proportionally more numerous, and came in more of their own accord than they ever did with the meaningless forms. This produced in the subjects the general opinion that in many cases the associations were really not needed for recall, that the pictures would have been recalled without them.

The total number of associations that were used in the four successive recalls and whose course could be traced throughout, and the total number of pictures involved in these associations are given in the following table:

1ST RECALL.		2ND RECALL.		3RD RECALL.		4TH RECALL.	
Assoc.	Pictures Involved.	Assoc.	Pictures Involved.	Assoc.	Pictures Involved.	Assoc.	Pictures Involved.
24	63	15	33	18	32	16	41

From the previous description of the different kinds of associations, it will be remembered that an association usually involved more than one picture. The conditions of the experiment gave a total possible number of pictures that might have been involved in associative connections at each recall of 96. This gives some measure of the prominence of associative recall. The irregularity of the figures for the second to the fourth recall is evidence of a complexity of the factors involved; they cannot be adequately determined from present results. But in general it is clear that a good share of the associations used in the first recall are not so used in the later ones, approximately a third, on the average, have dropped out in the latter. From other results we might expect the presence of several factors that would influence the use of associations. First, with the repetition of recall, if it is frequent, the direct visual images of the pictures gain relatively in spontaneity and associations drop out. Second, with the lapse of time, if the recall is relatively infrequent, the visual images lose in spontaneity and require former associations for their recall. Third, with the lapse of time the associations are themselves forgotten.[1]

[1]These three tendencies were found in the memory for meaningless visual forms. See pp. 330-333 of study referred to above.

(b) Their Changes. The general character of the associations in the successive recalls indicates that the two or three pictures that are thus connected, together with the imagery of the associations, constitute a complex of some degree of unitariness. The pictures 'belong together,' seem somewhat separated from the rest in the sense of possessing characteristics that the others do not share, the transition from one element in the complex to the other is very easy, and most of all, there goes with it an affective tone that is characteristic of these other qualities. The complex, however, is a loose and very unstable one. In any given recall, the repetition of such a complex, just as it had appeared in the previous recall, was a very rare occurrence. These changes may be considered under two classes. First, those taking place in the arrangement, relative prominence, and number of elements in the imagery of the associations themselves. Second, disregarding this first class, changes in the way and point at which the associations came in. Considering the latter first, the results show a process of a gradual elimination of the associations. The figures given above show that a good many that were used in the recall on the first occasion were not so used in the later recalls. But there are intermediate stages before they disappear altogether. Allowing for many exceptions, the order is as follows: (1) The association comes in before any of the several associated pictures are recalled. (2) The association appears after the first or second picture is recalled. (3) The association appears after all are recalled. (4) It does not appear at all. Taking the twenty-four cases of associations used in the first recall, and in the first of these four ways, through the second to the fourth recalls gives 72 instances in which these associations might have been used in the last three recalls as they were in the first. But in the last three they appeared in the four ways indicated. Their distribution for these four ways is as follows:

(1)	(2)	(3)	(4)
43%	22%	14%	21%

The other class of changes, the changes in the imagery that constituted the associations themselves, were equally prominent, and the direction of the changes with the lapse of time and the repetition of the recall could also be definitely traced. The predominant tendency was that of a rapid simplification of the imagery, though some other changes, leaving the total imagery equally complex, were also present in a much less degree. Simplification affected all classes of associations, visual and verbal, excepting those cases in which the associative connection consisted merely of combining the names of several

pictures into a phrase or sentence. Other cases of verbal imagery made up of a phrase or short sentence would be very readily reduced to a single word or two. Complex visual imagery would be readily reduced to a single factor of the original. A still further simplification was frequent in the different recalls. In this the only representative of the original association was the 'feeling' that there had been some connection before. The subject would, in these instances, approach the recall of the several pictures that had been associatively connected before with the distinct, very clear consciousness that such association had existed, but would recall the pictures without the appearance of that former visual or verbal imagery that constituted what he called the association. Such an independent feeling of the existence of an association preceding the recall was the form in which the original association persisted in 17% of the cases in which an association was used in the last three recalls.

3. *The Verbal Imagery.* The verbal imagery falls into two classes: (1) The description of the details of the pictures, and (2) Their names.

(1) Description. Verbal description entered at two points in the experiment: (a) In learning the group of pictures the subject had incipiently to some small degree a tendency to describe the visual details. Then (b) at each recall his introspective report necessarily involved detailed description of how he visualized the pictures. These descriptions might thus have been expected to play a part in the later recalls as a means to recall or to reinforcement of recognitive certainty. But as a matter of fact, no description used in learning was ever used or present in later recalls. Verbal descriptions used in previous introspective reports were sometimes recalled; the subject remembered what he had said before, but, considering the results as a whole, this was quite exceptional. The general procedure of the subject was decidedly independent of any memory of what he had said at a previous sitting. A further rather significant fact was that when he did clearly recall a previous description he often put very little reliance on its accuracy as regards the points in the picture described. Present visual imagery, though in itself uncertain in character, seemed more acceptable than the clear recall of description, if the two in any way contradicted each other. On the other hand, when the recall of a description agreed with a somewhat wavering visual image that was recalled first, the verbal memory, with some exceptions, quite readily induced the acceptance of the visual as correct. It reinforced recognitive certainty. The recall of previous description as the sole basis of accepting any point about a picture as correct occurred only a few times.

(2) The Names. The name of the thing in the picture also entered the process of recall in two ways. First, naming followed quite reflexly the appearance of the visual image, the subject being entirely unaware of any intermediate imagery, visual or auditory, of the name. Second, the auditory image of the name entered either before or after the visual image of the picture appeared. In about three-fourths of the cases the subject could tell clearly the order of succession. These give a means of determining the rôle of the name in the recall of the visual image.

It will be remembered that in the trial recalls, during the learning of a group of pictures, the subject's attention went first to the recall of the series of names. This was, without exception, never the case in the recall later. In these the subject's attention was always directed to getting the visual images, either directly or through the associations. At each sitting each picture was recalled twice; first in the general recall of the pictures as wholes, and shortly afterwards in the recall of the details of each individual picture. The following figures give the general percentages of the number of times (a) the visual image appeared first, (b) the verbal appeared first, (c) the visual and verbal appeared simultaneously, so far as the subjects could judge.

	a	b	c
General recall,	77	15	8
Detailed recall,	86	11	4
Average,	82	13	6

This shows at once the very great predominance of the visual imagery over the verbal, and the rather small rôle of the latter in the recall itself. As to its use when it appeared after the visual imagery, it may be stated at once that the name never seemed to affect recognitive certainty at all. Its presence was useless in these cases. The percentages show also that the visual imagery gains in spontaneity with repetition more readily than does the verbal. Since in each case the subject had to name the pictures in his report as well as visualize them, the procedure should not have greatly favored one class of imagery over the other. But it is seen that in the detailed recall the visual is first in 9% more of the cases than in the general. This relation can be followed further by comparing the different recalls with each other, from first to fourth. The following are the percentages:

	1st recall.	2nd recall.	3rd recall.	4th recall.
Visual first,	76	76	89	89
Verbal first,	17	15	11	7
Simultaneous,	7	9	0	4

If, in connection with the relation of visual priority in the general and detailed recalls, it is remembered that in the first recall the general was omitted, it is seen in these last figures that the priority of the visual imagery increases considerably with repetition of the recalls. In the first recall the average for the priority of the visual imagery would be several per cent. less if a general recall had been included. Put into general form, the last two tables mean that with the repetition of the recall the verbal imagery is eliminated from a place where it is not absolutely needed. The visual imagery gains in spontaneity, as compared with the verbal, and is recalled directly. The verbal comes in only after the visual, at a point where it is needed for the purpose of description.

4. *Some Visual Antecedents.* Two kinds of visual imagery that often preceded the recall of the visual image of the picture itself may be given a passing notice. To the subjects their significance never seemed great. But in analyzing the results it appears that the one class at least may have been of considerable use. This is the visual imagery of the rectangular paper with the regular arrangement of squares in which the pictures were placed. The other is the visual image of a dark, quite characterless blotch in the position of the picture, and in some way representing it. The former was of somewhat varying character. Its presence or absence in the first place depended on the ease of recall, the lapse of time, and the absence of associative recall. In the later recalls it was much less present than in the first. Recall through associative connections tended to eliminate it, especially if the recall was easy. In general, it appeared most when there was some interval between the initial effort to recall and the actual recall. It varied in completeness and in the definiteness with which all the squares were simultaneously visualized in a single image. As the extremes, there was, on the one hand, a definite and clear image of the rectangular piece of paper in proper size, color and distance, with a less definite and complete visual image of its 12-15 squares. At the other extreme, this visual antecedent consisted of the visual image of a few squares only, with an indefinite margin, the subject not being conscious of the rectangular form of the piece of paper, of its color, or that it was paper, and it was less definitely fixed as to distance, usually farther off than the original reading distance, and considerably enlarged. It seems safe to attribute to this visual antecedent at least one important function in recall. It gave a means of guiding and fixing the attention. With this visual map before him, the subject could halt his attention and concentrate his efforts on the recall of one individual picture, and could rally his associative aids around this one position until

the picture was recalled. Without such a visual map of positions, or its equivalent in associative connections, he had no starting point, no clue, could not concentrate his efforts, and could do little more than simply wait and let the recall take its own, spontaneous course.

The visual image of a dark blotch in the place of a picture that preceded the recall of the picture itself was often present when the recall did not take place readily. No instance, however, occurred in which it involved any characteristic other than size, position and an indefinite roundness of form. Nothing in it distinguished one picture from another; it contained no clue to recall. Apparently it served no purpose like those of the other aids to recall.

D. The Visual Imagery in the Recall of the Details of a Picture.

We have now to consider the analysis of the recall process after some sort of visual image of the picture as a whole has been obtained, a visual image that has been sufficient perhaps merely to allow the naming of the object and the recognition of the picture recalled as one that belonged to the group memorized. The recall of the details was then a second step, although in individual cases a line could not always be drawn definitely between the two parts of the recall. The details of the simplest of the pictures used were too many to be included in one span of consciousness. The process of their recall was therefore necessarily a succession of imagery of some duration. This was decidedly a visual process. Practically no secondary imagery other than visual ever entered as an aid to getting the visual details after the visual image of the picture as a whole was once reinstated. We have, therefore, in the further analysis of the recall process to consider visual imagery alone. A prominent feature in this was the appearance of much imagery that was wrong. This wrong imagery we shall discuss in the section on "Changes in the Content of the Imagery," after taking up first the general character of the process of the recall of details independently of this wrong imagery.

1. *The General Character of the Process of Recall of Details.* (a) Differences in the First and Last Parts Recalled. A few items may be noted first of all in regard to what appeared first in the total imagery and its relation to what followed. The order of the recall of details brought out very clearly the degrees of difference in spontaneity and ease of recall for these details. The easiest was recalled first, and that ease was due not to previous associated imagery, but to the inherent character of the imagery itself. This was shown first of all by the fact that the details that were recalled first were in so many

cases always the same parts of the picture. Other characteristics point to the same general fact. In a good share of instances the first details recalled and what followed were quite distinct in either one of two other ways. First, there might be a considerable interval following the first part before the rest could be recalled at all. Second, the imagery for the first part would be fixed in its character, the following part wavering in both its content and in the degree of certainty that went with it.

(b) The Criteria of Correctness. The recall of details was essentially a process of reconstruction. On the whole the final product that was accepted as correctly representing the original picture was the result of many eliminations and variations of visual details that suggested themselves spontaneously. Usually it was not so much a matter of filling in details somehow or other as it was a matter of deciding which of the details that were readily imaged were the correct ones. The general nature of the process is, therefore, best described further by considering the criteria of correctness and the manner of their use.

Although customary usage applies the term 'recognition' to all such criteria, the present results call for some discrimination. The form and content of consciousness that led the subject to accept a certain detail in the imagery as correct were of several different kinds. (1) Direct recognition may be mentioned as one of these. The term is used now in its most technical sense. In these cases the subject regarded the detail in question as right or wrong directly; he was unable to detect anything, in the character of the imagery itself or in the total process, on which acceptance or rejection might be based. Such recognitive consciousness was not, however, necessarily an immediate result of the imagery. It might appear only after some considerable attention to the imagery, and attempt at decision in some other way. Direct recognition was the most important way of deciding, but it was oftener than not accompanied by other factors as aids. (2) Inherent spontaneity in the imagery frequently led to its acceptance, especially in the absence of other criteria. The influence of this was brought to light clearly in cases in which a detail was visualized in two different ways, neither of which was recognized directly as right or wrong, and either of which might have been correct, so far as other details were concerned. If in such cases there was a distinct difference in the ease, vividness and spontaneity with which the two images appeared, the one having these qualities in the most marked degree was usually accepted, or at least favored as regards correctness. On the other hand, spontaneity and vividness were very readily re-

jected as criteria of correctness in favor of even a slight degree of recognitive consciousness attaching to competing imagery. In numerous instances the subject described certain imagery as very easy to get and vivid, and yet rejected it in favor of other imagery which he faintly recognized as correct, and which at the same time might have been very difficult to get and to hold. (3) The absence of rival imagery increased the tendency to accept whatever did present itself. The effect of rival imagery was shown in instances in which the subject at first recalled a detail in a certain way and accepted it as correct, but a moment later became doubtful of it or even rejected it when another suggested itself, which in itself seemed to have nothing more in its favor than that it was a possibility. In general, the suggestion of more than one possible way of recalling a picture created doubt where otherwise there might have been considerable certainty. Another tendency shown was that of rival imagery to drop out with the lapse of time and the repetition of recall. Where such was the case it was the rule of the subject to accept as correct what he did recall, though he had previously doubted its correctness in the presence of rival imagery. (4) Something in the nature of a process of inference was a very prominent method of deciding whether the imagery of a certain detail was correct or not, and was also a factor in producing that imagery in the first place.[1] This was so closely interwoven with the other factors that it was throughout difficult for the subject to detect its presence, or to say whether he believed a thing was so because of a direct recognition of its correctness, etc., or because he inferred it to be so on account of other things that he did so recognize or know. A detail might, of course, be inferred to be right for many different reasons. The results hardly allow any classification of the grounds for such inferences. Two sources, however, can be made out. First, the subject would recall certain details and be certain of their correctness. With this accepted, the nature of other details often followed necessarily. Secondly, in some cases he inferred details in the picture from what he knew of the thing represented by it, without any connection with details actually recalled. It is very evident, when other results in this connection are taken into account, that in very many instances some such process as this guided the recall and rejection or acceptance of imagery when the subject was not in the slightest degree aware that this was his method. Clear cases in which the subject reported that he

[1] The term inference, for want of another, is used here in a wide and loose sense, and is not to be defined in the formal way of the logician.

was inferring rather than remembering were very few, less than fifty in all the results. And in many of these he discovered this fact only after special questioning. On the other hand, memory illusions were numerous, but the details in these illusions were almost without exception wholly consistent with themselves. Though the subject constructed and accepted as correct a total image that was quite different from the picture, the construction was consistent with itself. It is clear, I think, that if that construction had been guided alone by direct, but in this case false, recognition and the other criteria of correctness already mentioned, it would frequently have resulted in a group of details for a picture that would have been quite inconsistent with each other.

The criteria of correctness changed somewhat with the lapse of time. In the first place, the general spontaneity of the imagery decreased. After the second or third recall it was evident to all the subjects that the pictures were recalled with much less ease, clearness, and detail. Second, the intensity of direct recognitive consciousness decreased. This took place, however, apparently from two quite different causes. For a few of the details that had always been very readily recalled and with perfect certainty as to correctness, the imagery came to be accepted later in a rather matter of course way, an attitude which, in the perception of familiar objects, is described as 'cognitive' rather than 'recognitive' consciousness. On the other hand, more frequently the intensity of recognitive consciousness decreased because of a loss of memory, the subject being less rather than more certain of the correctness of the details in question, so far as direct recognition was his means of judging. Thirdly, in some cases rival imagery dropped out. Details that were at first imaged in more than one way, the subject being uncertain as to which way was correct, were later imaged in one of the former ways only, the old alternative not occurring to the subject at all. In other cases rival imagery appeared in the later recalls that was not present at first. This seemed in general related to a decrease in certainty, from whatever cause, for some details. Certainty at first for a given detail barred out rival imagery. Later uncertainty gave the possibility of that detail being imaged in other ways and with an equal claim to correctness.

2. *Changes in the Content of the Imagery.* We may consider next the general character of the changes that appeared in the content of the imagery with the lapse of time. By changes in the content is meant now wrong imagery in the later recalls for details that were in the first recalls imaged correctly. These changes fall conveniently into two classes. (a) Imagery that presented itself more or less spontaneously, but which the sub

ject regarded as wrong. I shall call this conscious change. (b) Imagery that was wrong, but which the subject regarded as correct, illusions of memory. For the purpose of description these may be kept separate. But we shall see later that they are more closely related than their separate description might indicate.

(a) Conscious Changes. Following distinctions made in describing the criteria of correctness, the conscious changes in the imagery were of two kinds. First, the changes that were directly recognized as wrong. Second, the changes that were inferred to be wrong because of other known facts. These were the two methods that the subject was conscious of using in judging imagery. By far the greater part of the cases belonged to the former. As stated before, the recall was a reconstruction process consisting essentially of eliminating wrong imagery and deciding on what was wrong and what was correct. The tendency for imagery to come up that was at once recognized as wrong increased decidedly with the lapse of time. In some individual cases it bore the further characteristic of a high degree of vividness and persistence. Although at once regarded as wrong, the subject had difficulty in dispelling it. In the case of one subject such imagery was so prominent as to attract his attention and occasionally call forth generalizations on his own part. Thus in the third recall of one picture he said, "I find it very difficult to get a visual image that can be accepted. Various kinds of details come up that are at once recognized as wrong, but which, in the inability to get correct ones, are persistent." In the fourth recall of another picture he notes: "A number of visual details come up that are at once recognized as wrong. The visual imagery of these details comes up readily and clearly, while at the same time different details that are recognized as right are vague, hard to get and to hold." Such descriptions never occurred in the first recalls, and only a few times in the second, while they are frequent in the third and fourth. The generalization of this subject is verified by many concrete descriptions that state just what the imagery was and the whole process that ended in the acceptance of certain details as the correct ones. There was, however, apparently considerable individual difference among the five subjects on this point.[1]

[1] This individual difference appears in the introspective notes, when they are taken literally. I am not certain, however, but that the subjects were more alike in this respect than their own notes would indicate. Occasional special questioning showed that their *habits of introspective observation* were different, and in such a way as to account for a difference in their reports where the process of recall might have been really quite the same. In all there was a strong

What was said above of the grounds for inferring imagery to be correct holds true in quite the same way of the grounds for inferring imagery to be wrong. Imagery was inferred to be wrong from various reasons. To the two sources of inferences in the former case must be added now a special class, inferences based on the memory of a generalization made about the pictures. There were no colors in any of the pictures, and, of course, no motions. The subject could not forget these general facts. In the later recalls the things in the pictures were very frequently visualized in colors, and some of them as moving. These characteristics of the imagery were, of course, readily detected to be wrong. Every one of the pictures was visualized in colors at one time or another in the later recalls by one subject or another. These colors were always the natural colors of the objects represented. A further peculiarity was then the fact that in some cases only a part of the object was visualized in its natural color, while the rest was imaged in the black and white of the picture. In the picture of a child, for example, one subject imaged its hair as brown, with no further color. Another subject imaged a ribbon in pink, with no further color in the dress. In a picture of a human eye the iris was imaged as blue, with the lids and brow in the black and white of the picture. The ends of the handle of a jackknife were imaged in brass color, the rest in black and white. The drumsticks with a drum were visualized in wood color and black paint, the drum itself in black and white, etc.

The objects were also imaged in motion, but more rarely than in colors, a fact evidently dependent on the nature of the object, for not all the objects pictured were mobile. There is some slight evidence also that those objects in which motion might have been imaged were not imaged in that way so readily as in colors. I quote a few of the more striking cases, which reflect the general character of this class of conscious changes. Third recall of a picture of a locomotive: "With

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tendency to attend only to the final product of the process of recall, the imagery accepted as correct, and a corresponding disregard of the process by which this had been reached. Quite frequently the steps in the process were forgotten by the time the end product had been described. This fact has an interest independent of its present connection; for the strong tendency to direct the attention in this way seems to be an illustration of the fact that in everyday life we rarely are interested in *how* we attain an end mentally, but only in what we accomplish. In memory, especially, we have no practical interest in how we remember, but only in what we remember. The point of present importance in this is the fact that the different subjects did not succeed equally in directing attention to the process, the antecedent imagery, as well as to the product.

further attention to the imagery the locomotive begins to move, especially the drive wheels and the piston rod. I see the puffs of smoke and steam. It is almost impossible to visualize it as standing still." Third recall of a picture of a top: "The visual image of a running top is persistent. With continued attention, it begins to wabble and sway, like a running top that is stopping." Fourth recall of a picture of a dog: "There is a little difficulty in visualizing the position correctly. The dog in the image keeps turning its head around to look at me." Fourth recall of a picture of a cow: "With further attention its head turns towards me. I see it move, with the added feeling that I am visualizing a real, live cow. This sort of imagery persists, and the visual image of the correct position comes out only in short flashes." The persistence of the motion and the relative inability to image the object as stationery was characteristic of the imagery of one subject only, and with him it was not true, of course, of all the pictures; but only one of the five subjects never reported motion in any of his imagery. Individual differences were greater in this than they were for visualizing the things in their natural colors.

It was stated that these conscious changes in the imagery increased with the lapse of time. Most belong to the third and fourth recalls. No imagery of motion belongs to the first recall. Taking the more prominent cases, 99 in all, of visualizing color or motion, gives the following distribution for the different recalls, first to fourth:

1st Recall.	2nd Recall.	3rd Recall.	4th Recall.
10%	19%	29%	42%

The conscious changes in the imagery directly recognized as wrong (the class mentioned earlier), because of their nature and number were too incompletely recorded in the notes to justify giving figures. But the record as it is, and the occasional generalization on the part of one of the subjects, indicate that their course was much the same as was that for color and motion.

Without discussing the conscious changes at this point, most of what is included in their description may be brought together under one generalization. The imagery tends, with the lapse of time, toward the imagery of the object represented by the picture, and with this change takes on characteristics that belong to the object, but which are not represented in the picture. It will be helpful to keep in mind this generalization in considering the next class of changes in the content of the imagery, the memory illusions.

(b) Memory Illusions. If the term were taken in its strictest sense it might be demanded that only those cases should be

called memory illusions which were due to false recognitive consciousness. I shall, however, not so limit the term, but shall regard all wrong imagery that is accepted as correct as memory illusion, no matter what the criterion for acceptance has been.

The general frequency of illusions could not be determined definitely in the present study because of the fact that time never permitted the subject to give a really complete description of the details of his imagery. But taking the results as they stand, they show a large percentage of illusion. Its amount varied much with the different subjects, and more still with the different pictures. For some pictures some subjects never made any misstatements. For other pictures some subjects, in individual cases, described three-fourths of the details wrongly.[1] Taking the more marked instances of memory illusions, 280 cases in all, we find the following individual differences among the five subjects:

Subjects,	1	2	3	4	5
Per cent. of illusion,	17%	25%	9%	29%	32%

The conditions of the experiment were the same for the first three subjects; for the fourth and fifth the number of pictures in a group and the time allowed for learning a group were less, and the intervals between successive recalls were greater. The individual differences were probably due, in part, to this. Dividing the subjects into two groups accordingly, and figuring the percentages separately for each group gives:

Subjects,	1	2	3	4	5
Per cent. of illusion,	33%	49%	18%	42%	58%

The first subject described less of the details in the pictures than any of the others. The third gave his introspections in considerably more detail than any of the others, though not describing more of the details in the pictures. This led to greater discrimination in the characteristics of the imagery, etc., and made him more guarded in his statements as to what he really accepted as correct. Nothing further was found that might account for the individual differences in the amount of memory illusion.

There was some data also on the relation of the amount of

[1] Several recent memory studies give results on the frequency of memory illusion. They show very great variations in the amount of illusion as dependent on the different kinds of material to be remembered, and other conditions. In the general average it amounts to about 20%. I have summarized most of these results in another place. See "Recent Studies of Normal Illusions of Memory," *Am. Jour. Psy.*, 1905, pp. 389 ff.

memory illusion to the lapse of time and the repetition of recall. At least the first recall compared with any of the later ones gives considerably less illusion. Taking the same 280 cases used above gives the following distribution for the different recalls:

1st Recall.	2nd Recall.	3rd Recall.	4th Recall.
15%	30%	25%	30%

The results do not permit a definite statement as to why the amount of illusion did not increase regularly with the lapse of time, but several factors should be taken into account. First, a number of the illusions that were present in the first recall remained fixed throughout. Secondly, in the later recalls many of the details in the pictures were forgotten altogether, thus eliminating the possibility of making misstatements about them. Thirdly, the efficiency of the different criteria of correctness did not decline at the same rate as did the ability to recall details at all. Thus the amount of illusion in any given recall might be more or less than it had been previously according as these various factors were related to each other at the given time.[1]

An attempt to classify the memory illusions for the sake of describing their general character from the standpoint of the details in the pictures that were changed soon revealed the fact that they were literally of all sorts. The range of their variety seemed limited only by the possibilities of the things represented by the pictures. Any change in the object represented, which would not make it different from what the object ever actually is, might be introduced. Different groupings bring out different aspects of the tendency to illusion. Thus (a) with reference to the pictures described, details not in the picture might be added, or the presence of some that were there might be denied, or the number of parts of one class in a picture changed. The relative position of different parts were changed, the form of a part described differently from what it was, or the position of the picture as a whole changed so as to give a different view of the object represented. Taking another standpoint of classification, (b) with reference to their permanency, some remained unchanged, as already stated with regard to some of those that appeared in the first recall. In a good many cases the subject wavered back and forth between two statements, one or both of which might, in a pre-

[1] Some figures from other memory studies show something of the relation of the amount of illusion to the lapse of time. These all agree in showing some increase with successive recalls. See summary of studies of memory illusion referred to above, *Am. Jour. Psy.*, 1905, p. 393.

vious recall, have been regarded as uncertain. A smaller number changed to a third and even fourth characteristic, without reverting to a former one. Classifying them (c) with reference to the way in which they entered, three sub-classes may be noted. In the majority of cases the details in question were simply visualized wrongly but 'recognized' as correct. No immediate clue to their origin was given. Many belonged to a class often noticed by casual observers. Details would at first be described wrongly but with uncertainty, or regarded as mere irrelevant imagery minus all memory sanction. Later the same description would be given, but without the previous uncertainty; it would be regarded as correct. A few clear cases occurred in which the subject simply reasoned wrongly in reconstructing his total image. He inferred that a detail must be so, on the basis of what he did remember of the picture or knew of the object, overlooking some other possibility.

Figures may be given for the classification from the first of these three standpoints (a) above. For they will reinforce a generalization of importance already suggested with reference to their causes. Taking the 280 cases used before, three classes may be made that cover all but 17% of the total number. These are (1) relation of parts changed, (2) the form of a part changed, (3) the position of the picture as a whole changed, giving a different view of the object represented, (4) the miscellaneous group containing the remainder of the cases, details added, details that were present denied, and the number of a class of things in a picture changed. The percentages of cases belonging to these classes are then as follows:

1	2	3	4
16%	34%	33%	17%

In considering these figures it must be noted that ten of the thirty pictures used were of such a nature as could not be affected by the first class of illusions, their being no parts to the objects represented whose relations could be changed and still leave the objects as they ever actually are. On the other hand, it should be remembered that there was much less occasion for the third class to be numerous than there was for the first or second; for there were necessarily much fewer whole pictures than there were parts in all the pictures. This brings out the fact that there was a specially strong tendency to illusion of the third sort; we may safely say, more than twice as great as for any other of these classes, although only 33% of the cases belong to it.

(c) Causes of Changes. A determination of the special causes of the changes in the content of the imagery with the lapse of time is in the present study for the most part a matter

of interpretation. Bringing together a number of salient features that the general analysis has revealed will throw some light on this question. In the first place, it seems quite evident that the conscious changes and the memory illusions are both due to one and the same general cause. This is expressed in the generalization already made that the imagery of the picture tends to the imagery of the object represented by the picture. Whether or not the change will be a memory illusion or the subject be conscious that it is a change depends on special and largely quite incidental conditions. The validity of this generalization follows from the fact that both the conscious changes and the memory illusions were of almost unlimited variety, but were never inconsistent with the possibilities of the object. As stated of the illusions, any change might occur which was not different from what the object ever actually is. It is reinforced by the special prominence of the imagery of color and motion, and by the predominance of memory illusions that involved a changed position for the object, the object turned around somewhat as a whole. The last could occur for the imagery of the object without changing the object, but it could not occur for the imagery of the picture without changing the picture.

Some reasons may be given why there should be this tendency for the imagery to change to that of the object. The first three are facts of observation in the present study. In the first place the general spontaneity of the correct imagery, the imagery of the picture as seen, declined with the lapse of time. The more this was true the more was given the possibility for imagery of the object to present itself. Secondly, spontaneity was to some degree a criterion for accepting imagery as correct and lack of it for rejecting it as wrong, giving a further cause for the right imagery to drop out and the wrong to remain. Thirdly, the intensity of direct recognitive consciousness decreased, and thus permitted the elimination of the right imagery in favor of other imagery that was wrong. These are negative causes, favoring the decline of the imagery of the picture as seen. On the other hand, it may be said that the objects represented rather than the particular pictures of the objects were more matters of everyday experience of the subject. The two were undoubtedly somewhat different in every case. Thus the imagery of the object was the more usual, customary, habitual, and the mind in making the substitution simply followed the law of habit. This is a generalization that has already been made from other memory studies, and the tendency in question may be accepted as a factor here. But there are additional reasons why this should be so for the memory for pictures. Pictures as such have not the interest

and emotional coloring that belong to the objects. Such emotional coloring, when it takes possession of consciousness, brings with it the visual imagery with which it is connected. Again, in so far as meaning and interpretation is read into the picture at all, so far, of course, the picture ceases to be what it is and becomes the object. The picture just to this extent creates the tendency to substitute the imagery of the object in its natural setting.

A few things further may be noted in summary in regard to what determines whether a change that has taken place in the imagery shall be a conscious change or memory illusion. We have found two general checks to illusion when wrong imagery appeared. First, recognitive consciousness, although declining in efficiency, is more persistent than the original spontaneity of the correct imagery. Wrong imagery may increase in amount and persistency, but the larger share of it is at once recognized as wrong. This is in accord with the fact found in other memory studies which shows that more things can be recognized as belonging to a previous experience when given a second time together with others than can be directly recalled without such second presentation. Secondly, inference from other remembered or known facts prevents illusion. Clearly this is what prevented imagery of color and of motion from becoming illusion. If some of the pictures had been colored, or if they had been objects, some of them in motion, mistakes would undoubtedly have occurred by attributing color or motion to individual cases where none had been present. As it was, the subject could hardly forget that no color or motion belonged to any of the pictures. In the case of imaging the object represented in the position represented in the picture there was no such check. The object could be imaged from any side or turned in any way. No generalization that might have been remembered applied, and we have consequently many illusions belonging to this class.

Finally, the varying relations of all these factors that produce changes in the content of the imagery account for the fact that the course of the increase in memory illusion through the four recalls was not the same as was the course of increase in the conscious changes.

E. Summary.

In the experiments above described the subjects all learned the pictures in regular order from left to right and from the top downwards. They also all alternated looking at the pictures with trial recalls, giving about half the time to the latter. Their stated purpose in this was to determine what needed special attention and what could already be recalled. While

looking at the pictures the attention went predominantly to noting the details visually. In the trial recalls, however, the effort was predominantly to recall the series of names of the objects represented. Calling the visual method the direct method of learning, certain aids to the visual process were used. These were the names of the things in the pictures, verbal description of their details, and associations with individual pictures and between different pictures. The use of verbal description for details was very rare. The use of associations was abundant. They were easily obtained, and were of a large variety.

Factors determining the order of recall of the pictures gave some evidence as to the factors present and their relative efficiency in the recall of the pictures as wholes. The order of learning was followed in the first recall, but this order broke up gradually with the lapse of time. Factors that tended to break up the original order were: (1) Differences in the inherent spontaneity of the imagery for the different pictures; (2) Special prominence of the imagery of associations; (3) A general visual image of the regular arrangement of squares in which the pictures were placed.

Associations were abundantly used in getting the visual image of a picture as a whole in the first recall. Approximately a third of them were *not* so used in the later recalls. When the associations appeared after the visual images of the pictures, they practically never reinforced recognitive certainty; they were not needed for this purpose. Changes occurred in the nature of the associations and the manner of their use with the lapse of time. The imagery of the associations together with that of the associated pictures constituted a loose complex. Time produced a gradual elimination of the associations from this complex, which, with many exceptions, ran roughly as follows: (1) The association appeared before any of the associated pictures were recalled. (2) It appeared after the first or second was recalled. (3) It appeared after all were recalled. (4) It did not appear at all. A second class of changes consisted in a rapid simplification of the imagery of the associations. In this a final stage before complete elimination was, in 17% of the cases, the mere 'feeling' that there had been some association before.

Verbal imagery used in recall was that of the description of details, and naming. Verbal description used in learning was never used later in recall. Verbal description used in an introspective recall was sometimes remembered in a following one, but the subject made little use of such verbal memory, and put little reliance on its accuracy. The naming of the thing in the picture followed its visual image reflexly, or an auditory

image of the name preceded or followed the visual image. When it followed the visual it never influenced recognitive certainty. In 13% of the cases it preceded the visual image and was thus used in recall. In 82% the visual preceded, and in 6% the two seemed simultaneous. The priority of the visual image increased about 10% during the later recalls, as compared with the first.

Two kinds of visual imagery, aside from visual imagery involved in associations, often preceded the visual image of the picture. These were a visual image of the rectangular piece of paper with its regular arrangement of squares, and the image of a dark, otherwise quite characterless blotch in the place of a picture in a square. The former varied considerably in its general character. Its main function seems to have been that of guiding and fixing attention in the effort to recall individual pictures. The latter did not vary in character for different pictures; it served no function that could be determined.

The recall of details of a given picture was necessarily a process of some duration. Some differences in the character and manner of recall were found for what appeared first and last in that process. The part recalled first consisted of the easiest details, which were apt to be the same in successive recalls, with the nature of the content of their imagery fixed, and the subject certain as to its correctness. For the last part the details entering varied more, the nature of the imagery was not so fixed, and the subject was less certain. The two were often separated by a considerable time interval.

The recall of details was further a process of *reconstruction*, a reconstruction by means of eliminating wrong imagery more than one of producing imagery that was right in the first place. The criteria by means of which imagery was judged right or wrong or because of which it was accepted or rejected thus become the essential part in the actual recall process. Several such criteria were made out. (1) Direct recognition, using the term in its limited, technical sense. (2) Special inherent spontaneity of the imagery frequently led to its acceptance, especially in the absence of other criteria. But this characteristic was very readily discarded as evidence of correctness in the presence of even a very slight degree of recognitive consciousness attaching to other imagery. (3) The absence of rival imagery increased the tendency to accept whatever did present itself. (4) Inference, using the term in a very loose way, was a prominent method of deciding on the correctness of imagery. Without special and minute attention, the subject found it generally very difficult to discover that this had been his method in cases where actually it was so. Inferences were made on the basis of details already definitely recalled,

and on the basis of what the subject knew about the things represented in the pictures. Indirect evidence from the memory illusions also indicates that this played a large rôle in recall. These several criteria changed somewhat with the lapse of time. First, the general spontaneity of the correct visual imagery decreased, Second, the intensity of recognitive consciousness decreased. Third, rival imagery dropped out in some cases; in other instances it appeared where it had not been before.

Changes in the content of the imagery that occurred may be described as: (1) Conscious changes, wrong imagery which the subject knew to be wrong, and (2) Memory illusion. In the majority of cases of conscious changes the subject knew the imagery to be wrong by direct recognition. Such imagery increased very much with the lapse of time, and had in some cases the further characteristic of a high degree of persistence. In a second class of conscious changes the imagery was inferred to be wrong from other data recalled or known. Among these the tendency to visualize color and motion in the pictures is of special significance. These were always the natural colors and motions of the objects represented. This tendency to color and motion also increased quite regularly from 10% of the total number in the first recall to 42% in the fourth. The memory illusions showed great variation in their general frequency for the different subjects and for the different pictures. Fifteen per cent. of the total number occurred in the first recall, with 30%, 25%, and 30% for the second, third and fourth recalls respectively. There was some additional evidence that a changing relationship of several factors, militating both for and against the illusions, determined their relative frequency at any given time. From the standpoint of the details in the pictures that were changed the illusions were limited in variety apparently only by the possibilities of the objects represented, any change being likely to occur that did not make the object different from what it ever actually is. Making an arbitrary classification from this standpoint showed that there was a specially strong tendency to illusion of the position of the object represented, *i. e.*, a changed view of the object.

One and the same general cause produced both conscious changes and memory illusions. This was *the tendency of the imagery of the picture to change to the imagery of the object represented.* Special reasons why this should occur are: (1) The spontaneity of correct imagery declined with the lapse of time. (2) Spontaneity, or lack of it, was to some degree a criterion for accepting imagery as correct or for rejecting it as wrong. (3) The intensity of direct recognitive consciousness decreased. (4) The object rather than its picture was more a matter of

everyday experience, and its imagery readier, and more habitual. (5) More interest and emotional coloring belongs to objects than to their pictures. (6) To the extent that the picture represents and suggests the object the imagery of the object is already given.

THE PSYCHOLOGY OF HUMOR.

By L. W. KLINE.

OUTLINE.

I. Introduction.
II. Grouping of theories.
III. Humorous and non-humorous stimuli.
IV. The nature and origin of humor as a mental process.
V. Functions of humor.
   a. Psychological
   b. Physiological
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I. INTRODUCTION.

Voltaire is said to have observed that Heaven has given us two things to counterbalance the many miseries of life,—hope and sleep. To these Immanuel Kant adds a third, laughter. No stimulus, perhaps, more mercifully and effectually breaks the surface tension of consciousness, thereby conditioning it for a new forward movement, than humor. It is the one universal remedy; a medicine for the poor, a tonic for the rich, a recreation for the fatigued, a beneficent check to the strenuous, a shield to the reformer and an entering wedge to the recluse. Barter and trade make a liberal use of it. A German writer observes that it is a parachute to the balloon of life. To change the figure, it is a switch on the railway of life preventing human collisions. It is a universal solvent to human temperaments, and like a touch of nature makes the whole world kin.

"Xenophon reckons that the man who makes an audience laugh has done a lesser service than the one who moves it to tears, but the comedian Philippos, when Socrates asked him of what he was proud, declared, 'I believe that I ought to be proud of my right to the gift of arousing laughter, as Kallipedes, the tragedian, of his art in causing tears.'" [1] Lycurgus even erected a statue to the god of laughter.[2] Cicero says that "it certainly becomes the orator to excite laughter; either because mirth itself attracts favor to him by whom it is raised, or because all admire wit—but chiefly because it mitigates and relaxes gravity and severity, and often by a joke or a laugh

[1] Nick, Fr.: Narrenfeste, Bd. I, 2. (1861.)
[2] Cicero: Oratory and Orators, p. 289.

breaks the force of offensive remarks which cannot easily be overthrown by arguments." It has remained, however, for the man of modern science and letters to indicate more specifically the problems involved in the origin and nature of humor. I need hardly state that the theories have multiplied in number and refinement to the point where their enumeration becomes tedious. It is a part of the purpose of this paper to go over the field with the hope of discovering a point of view that will resolve the seemingly diverse theories to a common basis and to restate more explicitly the psychological nature of humor.

II.

Grouping of Theories.

Groos[1] has attempted to reduce the multiplicity of humor theories to two, "that of the feeling of superiority and that of contradiction." Ribot[2] admits these as equally tenable, but gives some space to Hecker's "contrast and intermittence" theory as a third. I would add to these three groups a fourth, the "liberty" or freedom theory, first advanced by A. Penjon.[3]

It appears that Hobbes was the first to stand sponsor for the superiority theory. He expresses it as follows: "The passion of laughter is nothing else but sudden glory arising from sudden conception of some eminency in ourselves by comparison with the infirmity of others or with our own formerly." Sully,[4] in support of the theory, points out that "we laugh at all sorts of littleness, discomfitures, unworthiness and so forth, provided that they are not serious enough to excite compassion, to offend our sense of decency or evoke other incongruous feelings." Bain[5] observes that "the occasion of the ludicrous is the degradation of some person or interest possessing dignity in circumstances that excite no other strong emotion. . . . The element of the genuine comic is furnished by those dignities that from some circumstance or other do not command serious homage." The reader is referred to Prof. Bain's enumeration of the degradable quantities. Another means of degradation, according to Bergson,[6] is the mechanization of organic movements, the insertion of mechanism in life processes. A ready experiment is that of stopping one's ears to the music of the

[1]Groos, Karl: Play of Man, pp. 232-237.
[2]Ribot, Theodore: Psychology of the Emotions, pp. 352-357.
[3]Penjon, A.: Le Rire et la Liberté. Revue Philosophique, pp. 113-140, Aug., 1893.
[4]Sully, James: The Human Mind, p. 150.
[5]Bain, Alexander: Emotions and the Will, pp. 257-260.
[6]Bergson, Henri: Le Rire, Essai sur la Signification du Comique, Paris, 1904.

dance. The motions of the participants at once become ludicrous. The drill service of the army recruit, the divinity student making his maiden effort, the new clerk at the counter, the city chap trying to be "handy" on the farm, in fact the attempts of all novices are ludicrous because they convert organic into mechanical movements. Punch and Judy, jumping jacks, and all forms of punchinellos owe some of their oddity to their rigid and wooden movements.

Some of the more patent and random facts of the superiority theory are seen in the savage's laugh over a fallen foe, in the practical jokers guffaw at his victim, in the soldier's shouts of victory, in the wild uproarious shouts of the winners in many forms of political and athletic rivalry.

The theory of "contradiction" or "incongruity" has more adherents, perhaps, because the data forming the general notion is so plentiful, diversified and patent. This has led to its exploitation along seemingly different lines. Schopenhauer[1] and Kant and their commentators hold that the humorously incongruent consists in a comparison between a norm and its imperfections. For Schopenhauer the norm is a concept and the imperfection is resident in a related percept. He says: "Therefore in everything that excites laughter it must always be possible to show a conception and a particular; that is, a thing or event which certainly can be subsumed under the conception and therefore thought through it, yet in another and more predominating aspect does not belong to it at all, but is strikingly different from everything else that is thought through that conception." He thinks this is an explanation of the humor provoked by certain animal forms such as apes, kangaroos, jumping hares, etc. There is something about these creatures resembling man which leads us to subsume their forms under the conception of the human form, and starting from this we perceive their incongruity with it. Another variation of the incongruity doctrine consists in grounding the comic on a "baffled attempt" to unite incongruous parts into harmonious wholes. The baffled attempt may or may not be conscious. The conscious result is described as a "delicate, sudden surprise." Kraepelin[2] speaks of it as "an unexpected intellectual contrast which awakens in us a contention of æsthetic, ethical or logical feelings with a preponderance of pleasure." Dr. G. Stanley Hall[3] explains wit by this sort of incongruity which he thinks functions as a

[1]Schopenhauer, Arthur: The World as Will and Idea, Vol. II, pp. 275-280. Translated by R. B. Haldane and J. Kemp. (1819.)
[2]Quoted from Theodor Lipps, Komik und Humor, p. 29. (1898.)
[3]Hall and Allin: The Psychology of Tickling, Laughing and the Comic. *Amer. Jour. of Psy.*, Vol VIII, p. 27.

shock to the psychophysical organism. The common mind even speaks of being shocked by wits, jokers and punsters. Bain admits that the incongruous is ludicrous if it is degrading, while Spencer[1] urges its efficacy to produce laughter if it is descending but not necessarily degrading. Groos observes that these two theories (superiority and incongruity), are by no means exclusive the one of the other, but that they are only opposed in that each accuses the other of failure to cover all the facts. Sully and Ribot attempt to harmonize them on an evolutionary basis. The degradation theory explains the humor of the primitive mind,—the mind that gloried in the sudden sense of physical power and physical victory, while the modern mind finds enjoyment in incongruities, "in those fugitive and subtle contradictions which constitute the principal element of the comic to be caught on the wing." Groos absorbs both theories in one by considering the appreciations of the comic as a form of play grounded on the instinctive indulgence of the fighting impulse, aided and enlarged by the ideas of contrast.

Ribot calls attention to the fact that the nature of laughter (the comic) would be very incompletely known were we to confine ourselves to pure psychology. Humor is a psychophysical phenomenon writ large, of which laughter is the physical aspect. The causes of physical laughter are legion, and, as Darwin[2] has observed, extremely complex.

Spencer was the first to consider and develop a satisfactory theory of the physiology of laughter. He points out three possible channels through which nerve centres in a state of tension may discharge themselves. One group discharges into other cortical centres which have no connection with the bodily members, a second group discharges into motor centres and thereby causes muscular contractions, a third may pass on the excitement in centres which discharge into the viscera. The channels which discharge into the motor centres may cause laughter. "Laughter, then, is a form of muscular excitement" and so illustrates the general law that feeling passing a certain pitch habitually vents itself in bodily action. The movements of laughter are without purpose and aim. They yield no product. In this respect they are similar to shivering, to certain automatisms and to some forms of imitation and play. They seem admirably fitted as spill-ways for uncontrolled energy. And herein lies the explanation of why certain classes of muscles are affected first and then certain other classes. "For an over-

[1]Spencer, Herbert: Physiology of Laughter, Essays Sci. Pol. and Spec. Vol. II, pp. 452-466. (1860.)
[2]Darwin, Charles: Expression of the Emotions, pp. 352-354. (1872.)

flow of nerve force undirected by any motive will manifestly take the most habitual routes, and if these do not suffice will next overflow into the less habitual ones." The organs of speech furnish and are therefore the most frequent outlets for feeling. The muscles around the mouth are small and easy to move and are the first to contract under pleasurable emotions. The mouth movements are followed in order by those of respiration, then by those of the upper limbs, and if these latter are not sufficient, the more central and fundamental muscles of the head and body are brought into action producing the "hearty laugh." This explanation of the physical aspect of laughter has, so far as I know, been generally accepted in its main features.

In 1873, thirteen years after Spencer's paper, Ewald Hecker[1] published his unique "contrast and intermittence" theory, in which the physical aspect receives due attention. On account of its interest from an historical standpoint it is here briefly presented.

1. The vasomotor nerves which regulate the calibre of the smaller arteries can be excited reflexly by afferent impulses conveyed either from the blood vessels themselves or from the end organs of the sensory nervous system.

2. Those parts of the body rich in small blood vessels containing vasomotor nerves will experience wide volumetric changes.

3. Of such parts the brain is chief. Its delicate structure, its bony case and its large volume of blood together with other fluids make it highly important that the inflow and outflow of blood be safely regulated.

4. Such regulation is accomplished in two ways, (a) by changes in the calibre and the tonus of the blood vessels as indicated in principle 1 above, (b) by the rhythmic changes in the intra-thoracic cavity due to respiratory processes.

Hecker inferred from scattered bits of experimental evidence that tickling acts as a reflex stimulus to the vasomotor nerves, which in turn narrow the calibre and increase the tonus of the cerebral blood vessels, the result of which is to force the blood from the brain cavity, thereby inducing anæmia. It is further argued that inspiration co-operates with tickling in causing anæmia while expiration checks the blood flow from the brain, thereby restoring normal blood pressure. Any device, therefore, which prolongs expiration tends to correct the anæmic condition. For Hecker laughter is such a device; it is a biological activity developed through natural selection like any

[1]Hecker, Ewald: Physiologie und Psychologie des Lachens und des Komischen, Berlin, 1873.

other survival-value process. The laugh is a powerful reflex movement which compensates for the diminished blood pressure caused by the tickle.

We are not sure, however, that an anæmic condition of the brain favors laughter; it is a mere inference. A case can be made out in favor of hyperæmia and laughter,[1] not to mention the fact that the presence of vasomotor nerves in the vessels of the cortex is still unproven.[2]

Hecker's psychical account of laughter is grounded on the physical. Laughter as a mental process consists of an accelerated contention of feeling, of a hither and thither fluctuation between the pleasant and the unpleasant in which the unpleasant aspect is neglected, that is, is unconscious. Continued contention between the two feelings produces mutual intensification until, as in the comic, "pleasure is passing over into pain and pain into pleasure." This intermittent feature of the comic is analogous to that of the physical tickle, producing a similar anæmic condition of the brain. Here again physical laughter restores the normal blood pressure by prolonging the respiratory process. The defects in this theory have been pointed out by Hoeffding[3] and Lipps,[4] by the latter at great length.

The potency of these time honored theories stubbornly to resist a Hegelian synthesis and to perpetuate the irreconcilable camps is uniquely demonstrated by Miss L. J. Martin,[5] in her paper on the "Psychology of Æsthetics." Miss Martin presented to the view of her reagents a pictorial caricature on the phrase, "Spring, gentle Spring" by Mr. Kemble, of *Life*. They were asked among other things to assign a cause for the comic in the picture. Concerning "superiority and degradation," thirty-seven of the reagents have a feeling of superiority in connection with the Kemble picture. The remaining twenty-three report themselves as having no such feeling, while a hundred and eighteen interpret it under some variety of Schopenhauer's "contrast theory."

The sections that follow consider the "Liberty" theory and its possibilities for absorbing its predecessors.

III. Humorous and Non-Humorous Stimuli.

The immensity of space, the infinitude of time, the alternation of day and night, the movements of the heavenly bodies,

[1]Stewart: Manual of Physiology, pp. 254–255.
[2]American Text Book of Physiology, p. 204.
[3]Hoeffding, Harald: Outlines of Psychology, pp. 291–292.
[4]Lipps, Theodor: Komik und Humor, pp. 9–15.
[5]Martin, L. J.: Psychology of Æsthetics, *American Journal of Psychology*, Vol XVI, pp. 108-109.

all rhythmical changes, never inspire humor. The same thing is apparently true of all physical, chemical, and mathematical laws, and, likewise, of the macroscopic things of earth, the waters, tidal movements, cataracts, mountains and forests, deserts and plains. According to Schütze,[1] dead things, rocks, stones, rivers, are never laughable unless human qualities are ascribed to them. Bergson declares "There is no comic outside of what is properly human." Organic life in the large, such as swift, rhythmical movements of large numbers of animals, may inspire awe and dread but never humor. The orderly expression of life processes, such as the heart beat, the mystery of sleep, self-consciousness, birth and death, give no sense of humor. There is a large group of objects, situations and actions which incite feelings of disgust, of loathing and even hatred. Of objects there may be mentioned parasites, creeping, crawling and slimy things, all filth, all skin and eye diseases; and of actions, all forms of tyranny and bullying, treachery, poltroonery, ingratitude and, according to Bain, the "entire catalogue of the vanities given by Solomon."

There are a large number of objects which, so far as humor is concerned, constitute an indifferent zone. Subdued colors, gray tones, all natural forms of locomotion and movements, all common and customary occupations, all actions and events of familiar notice belong here.

By this process of elimination it appears that the conditions averse to humor are, (1) the macroscopic things of the world together with their laws, order, harmony, and rhythm, (2) those things which are inimical to life and freedom, (3) those things, largely of the social order, that have become habitual, regular in occurrence and necessary to human comfort. There are left for consideration animals and their actions, man and his actions, clothes, customs, manners, words, language and thoughts.

1. *Animals.* Small animals, like small people, are more likely to provoke humor than large ones. The bantams and games are the clowns and Don Quixotes of poultrydom, while the Plymouth Rocks and Shanghais are the prosaic members. The poodles, terriers and spaniels are the fun makers of the kennel, the St. Bernards, great Danes and bull dogs command our serious respect and sometimes more. When an animal of one class does the task common to an animal of quite a different class, it is apt to provoke humor. An ox in shafts drawing a top buggy; mules, asses or buffaloes running a race; an elephant drawing a chariot are examples. But if the animal is set

[1]Schütze, Stephen: Versuch einer Theorie des Komischen, p. 36, 1817.

to doing a human task the humor is intensified. The inimitable Æsop, endowing animals with human craft and qualities, made this style of humor classical for all time. It appears in modern humor in the doings of Johnny Bear, in the clever tricks of Brer Rabbit and Brer Fox, and in the county fairs, charity balls, political conventions, clinics for appendicitis and the like conducted by divers species humanly socialized.

2. *Man.* Man may provoke humor by his size, especially if extremes meet. The undersized is likely to amuse, especially in his pretensions and passions. Unusual features, types of ugliness, odd shapes, and Falstaffian proportions contain humorous elements.

3. *Actions.* Mimicry and all actions of a pretentious and useless sort, and in false time and space relations may provoke humor. All mimicry is humorous, whether in the form of the puppet show, the pantomime, the burlesque or the comedy. The pursuit of uncertain pleasures,[1] idle, and sometimes serious, gallantry, premature and rustic courting readily classify with humorous actions. Useless actions of the ideomotor and absent minded type are the causes of many of the comedies of errors in every day life.[2] Examples are numerous: A young lady partially disrobed to make a toilet at the noon hour and wound up by "saying her prayers," that being her usual next step in the evening. We recall also the well-known anecdote of Newton, who carefully put his watch in the kettle, and resumed his mathematical labors with the egg on the table beside him to indicate the time. The wrong use of objects, tools and machinery often make an act humorous, for instance, an Indian purchasing a hearse for a carriage and taking his family to church in it. Awkwardness is a common type of action naturally humorous. Any action inherently serious may become humorous by occurring either out of time or out of place. Singing ahead of time, applauding alone, answering questions at the wrong time on formal occasions, an unmindful deacon removing his small coat with his overcoat and sitting down in his shirt sleeves in church, are cases in point. Hazlitt remarks, "in jocular history everybody is at angles to real life; people do precisely what they ought not to do, say what they ought not to to say, are found where they ought not to be found."[3]

4. *Clothes.* Clowns and professional fools supplement their wit, humor and mimicry by their well-known forms of dress. Johnny Bull, Uncle Sam, Santa Claus are always good-na-

[1] Hazlitt, William: English Comic Writers, p. 14. 1819.
[2] Jastrow, Joseph: On Lapses of Consciousness, Pop. Sci. Mo., Oct., 1905.
[3] Hazlitt, W. C.: Studies in Jocular Literature, pp. 221-222.

turedly received, partly on account of their dress. Halloween, masked balls, Mardi Gras and carnivals, ancient and modern, owe much of their charming good humor to dress. It is well known that we laugh at the dress of foreigners and they at ours. "Three chimney sweeps meeting three Chinese in Lincoln's-Inn-Fields, laughed at one another till they were ready to drop down. Country people laugh at a person because they never saw him before. Any one dressed in the height of fashion or quite out of it is equally an object of ridicule." Doubtless if the centuries could rise up and view each other *en masse*, their first act would be mutual laughter at each other's clothes.

5. *Customs and Manners.* As stimulants of humor customs and manners have, perhaps, no equal. They excite it alike in the vulgar and in the cultured, in the illiterate and the learned. They appear in excesses and exaggerations and in violating time and space relations, either as innovations or as lingering too long. To appear in excess or out of time and place implies some age and stability in human institutions. Norms and standards of fashions must be formed, regularity in activities must freeze into custom and the free spirit of good fellowship and of social intercourse must become habituated to the plane of manners before the spirit of satire, wit and humor can react for or against them. This is so apparent in the literature of every people that it seems unnecessary to make special references.

6. *Words, Language and Thought.* This is the favorite tramping ground for both the humorist and his critics. Here occur the most delicate, subtle and refined specimens. It is also here that an attempt to give an adequate treatment resembles trying to bottle a fog or lasso a cloud. To make some headway, however, we are under the necessity of drawing a few distinctions. All words, language and thoughts not humorous to the speaker but so interpreted by the observer may be termed *unconscious humor* (following the lead of common usage). The humorous interpretation of unconscious humor may be called *passive humor*. All deliberate use of words, language and thoughts and the exploitation of all other humorous stimuli by the subject for humorous effects may be considered *active humor*. In what follows the text indicates which sort is meant.[1]

a. Concerning words it appears that their misspelling, mispronunciation, misinterpretation, forced and misusage, punning, repetition, localisms, foreign accent and even intonation

[1] For a discussion of the forms of the comic, see Lipps: Komik und Humor, pp. 78-102.

endow them with a certain degree of humor. Many of the humorous classics use one or more of these methods. The writings of "Artemus Ward" and "Josh Billings" practically exhaust the possibilities of misspelling. All forms of dialect now occupy much of the humorous field of mispronunciation and misinterpretation. Dickens displays the worth of forced usage in the inimitable Pickwick. Sheridan creates Mrs. Malaprop largely by these methods. Shakespeare had the courage to pun to his own satisfaction. Dickens again has used repetition to a fine effect in several of his characters. We recall Mr. Toots, "of no consequence" and Joey Bagstock who is "devilishly sly." Provincialisms and foreign accents enter into the humor of daily life more than into that of literature. The unconscious distortion of words by the illiterate, the naïve and the pretentious adds to the quality of this sort of humor. In fact, whether the distortions are "made" or are unconscious, their humor depends on our apprehending them as unconscious. A farmer who made daily business trips to Richmond assured his neighbor that he always dined at a "first-class reservoir." A colored servant in my own home asked for a half holiday to go on a "railroad 'squashin.'" (What irony in the light of recent events!)

b. Language, much more than customs and manners, requires a civilization of some age and stability in order to furnish both the conditions and the material for humor. George Meredith[1] has urged that a society of cultivated men and women is required wherein ideas are current and of some duration, and the perceptions quick that the humorist may be supplied with matter and an audience. "The semi-barbarism of merely giddy communities, and feverish emotional periods" create no humor. Quaintness in language, as in other things, gives a tinge of humor. A description of the table manners of a nun or of a lady of culture in modern language would be sorry business, but when Chaucer says of the nun,

> "At mete wel y-taught was she with-alle;
> She leet no morsel from her lippes falle,
> Ne wette hir fingres in hir sauce depe."

he stimulates our sense of humor. Here belongs the grave and serious style in connection with trivial and prosaic matters. Many of the failures of language to fit the thought yield humor, a common type is verbosity. In this connection I may cite the following, which is supposed to come from the Mt. Sterling, Ky., *Reporter* (Colored):

Dear Editor:
Please allow me a space in your momentous Gazette to reciprocate

[1] Meredith, George: An Essay on Comedy, p. 8, London, 1905.

my gratitude to the indefategably workers of the Evergreen Baptist Church. While sitting in my studio last Friday evening greatly obsorbed in the momentous problem so called Negro problem I were interrupted by the anthem "There shall be showers of blessing" which rendered me surprisal happy. . . . . After a general parlance I were divinely impressed to descant on the altronistic spirit that should characterize the christiandom. A sumptuous repast followed and all present shiated their gastronomic desire. Bro. Ben Mitchell distinguished himself from the rest by his implacable vorasity. May God bless the members of the Evergreen Baptist church. Many thanks. *F—— B——, Pastor.*

Ultra slang, brusque catch words and phrases of common life may provoke humor for a short period. This field is illustrated by the monologues of Chimmie Fadden and the writings of George Ade. The speech of the excited, the irritated and the fatigued is often rendered humorous by inversion, omissions and awkward substitutions. A prospective bridegroom at the church door in consultation with his minister inquires excitedly, "Is it kistomary to cuss the bride?" Grumio answers his master, "Ah, sir, they be ready; the oats have eaten the horses." Taming of the Shrew, Act III, sc. 2.

c. What a man thinks or feels, although serious to him, may be just as much an object of humor as a situation, an awkward movement or a form of speech. The unconscious maker of humor in thought is my next neighbor. More specifically it is the illiterate, the ignorant, the inexperienced, the credulous, the skeptic, the superstitious, the over-serious, the vain and the prosaic. The humor usually appears in the attempt to deal with situations and problems somewhat beyond their ken. The ignorant and illiterate amuse by their literalisms, pretensions, evasions and superstitions. Dickens makes frequent use of this form of humor, witness Joe Gargery's pretensions at reading for Pip's benefit. Thackeray's Captain Rawdon Crawley is a fine specimen of stupid ignorance. Many superstitions are kept alive by their humorous vein.[1] Inexperience is the lot of childhood and its humor is expressed in its questions, in its wonderings and its explanations. This is abundantly verified in the literature of childhood, now occupying excessive space in current magazines. The humor of the credulous appears in a condensed form in their responses to the yarn-spinner and prank-player. The faith and works of the inventor are often ahead of his time and are therefore the butt of the common mind. Cervantes made Don Quixote the prince for all time of the over-serious, and Malvolio of Twelfth Night typifies the vain among individuals of small parts. Delivering great force into small matters, exercising

[1] Johnson, Clifton: Some New England Superstitions: New Eng. Mag., Oct., 1906.

much thought over petty questions, exalting trifles to the plane of the magnificent form a perennial source of humor.

Active-thought humor. Active-thought humor is as complex and infinite in variety as thought itself. Its consideration naturally belongs with that given to the *nature* of humor in the next section. It is taken up here for the reason that it employs a wider range of humorous stimuli than that just detailed. Perhaps the earliest form of this humor is expressed by the child in its "surprise" and peek-a-boo plays. While learning to talk it uses mimicry to good effect and a little later imitative and even original tricks are performed for amusement. From about four years old to ten original humorous drawings are made with considerable zest. As soon as they acquire some degree of familiarity with the mother tongue, guessing games, riddles, conundrums old and new, rhyming, punning and joke-making are used with greater or less frequency for humorous purposes. This period naturally connects with the drollery, clownishness and prank-playing of adolescence—a period rather barren in creative humor. Adolescence laughs much but creates no humor, so far as I can ascertain. The gravity of life is dawning and self-consciousness is too frequently on guard, thereby precluding the conditions for creating humor. Cicero[1] was the first to have extensively considered active-thought humor in adult life. He apologizes for his number of headings. "I have divided these matters into too many headings already—but in general their varieties are reducible under a few general heads; for it is by deceiving expectation, by satirizing the tempers of others, by playing humorously upon our own, by comparing a thing with something worse, by dissembling, by uttering apparent absurdities and by reproving folly that laughter is excited." Elsewhere he includes "pretended misunderstandings, wishing the impossible, uniting discordant particulars, and concealed suspicion of ridicule." Of course it is evident that the wit and the humorist employ these several means together with those I have already described, while the cartoonist adapts the same principles to the pen and brush.

IV.

The Nature and Origin of Humor as a Mental Process.

Schütze in 1817 and Hazlitt in 1819 résuméd the various opinions as to the nature of humor up to their time. The former cites some fifteen different authorities and views.

[1] Cicero: Oratory and Orators, Bonn's ed., p. 303.

Schopenhauer in 1819 made a decided contribution in that he attempted an exact description of the mental processes involved. Since then the nature of the mental process and its physiological basis have been the main points of discussion. Schütze, Hoeffding and Sully call attention to the sense of freedom involved. Penjon in 1893 describes at some length the relation of this sense to humor.

I have already pointed out that the appreciation of law, of order, of harmony and of those things that are inimical to life and freedom begets a sober mental attitude, the intensity of which varies with the weightiness of the matter and the issues involved. Now if when dealing with such matters, the thinking process continues organized and controlled and progresses toward an end, it is termed rational. But if the mental tension exceeds the capacity for controlled thinking, brought on by the sudden triumph of wrong and evil values, disruption of the thinking process at once ensues accompanied by an unpleasant emotion ranging from mild disappointment to the tragic: if, on the contrary, the disruption is caused by the sudden triumph of good values, a pleasant emotion results. In either case organized and rational processes give way to those of an uncontrolled and emotional sort. The mental stream has had its banks torn away and its forward movement stopped, voluntary movements are replaced by hereditary. In the more intense form a reversion to primitive conditions may occur; for we then do and say things that may shame us in our sober moments. Now the humorous process occurs in just such a disrupted consciousness at the triumph of good and pleasurable values preceded by a mental tension similar to, but not always equal to, that preceding emotions. The common and quiet forms of humor usually occur in a consciousness that has been running at its usual strength and depth, sufficiently organized to command the situation, assume a definite form and take on a certain strength of surface tension. (The term, "surface tension," simply extends the water metaphors of psychology in a logical direction. I use it to indicate the impervious condition of consciousness formed in any attentive state, the strength of the surface tension being in direct proportion to the intensity of attention.) The function of the humorous stimulus consists in cutting the surface tension, in taking the hide off of consciousness as it were and in breaking up, in part only, its organization, which is at once followed by the humorous feeling, the next wave in the stream of consciousness. The cognitive elements in the humor process consists, (1) of the perception of the stimulus, (2) the sense of freedom. Each of these cognitive elements is suffused by pleasant affective elements which constitute in their totality the unique and dominant humor tone. The unique-

ness of the humor tone is the crux of the matter. The mental tension preceding the humor process is not the differentia, for that precedes any and all emotional states, yet it is an essential condition. The clue lies in the nature of the humor stimulus and the relation sustained to it by the individual. This stimulus belongs to an order of knowledge, whose laws, uniformities, manners and customs have arisen since the human mind has attained its present estate. Contrast with the humorous stimuli the non-humorous and it appears, humanly speaking, that the latter have always existed. The heavens, the laws of matter, cosmic forces of whatever sort were in full swing when human consciousness dawned, their operation has participated in mental evolution and to that extent has impressed law and order upon it. Therefore, when we are engaged with these things, sober thinking, pleasant or unpleasant emotions are the outcome, but never humor. "The spirit of mind in infancy may be through and through playful, but as it unfolds and develops in a world of order and law, it comes to operate in an orderly fashion. We see nature in terms of law and order, that is in terms of science."[1] But it will be noticed that the humorous stimuli are departures, exaggerations, even violations of the laws, uniformities, concepts and what not that have evolved out of man's experience. The significant fact for humor is that these departures, exaggerations, etc., do not disturb the recognized values of good and evil. The mind maintains all the while a disinterested attitude toward the object of its activity. We seek neither to correct nor further exaggerate the departure from the norm. It is time to feel and not to act. We enter into æsthetic rather than practical relations with the object of our humor; should we seek the practical the humor at once ceases, issuing, perhaps, in bitterness or joy, sarcasm or flattery, indignation or admiration.[2] Penjon writing upon this point says: "If one separates, as must be done, the causes which too easily deform the comic and make of it an emotion of wickedness or bitterness, the comic emotion will appear purely disinterested. I mean by this that the object or the event which is the occasion of the comic excludes every idea of loss or of profit, that it makes us conceive neither hope nor fear and seems to us at the same time neither advantageous nor harmful to any one; it is worth in itself what it is worth without adding to our idea of it any consideration of end or ideal." The humorous process, then, like play, is its own end and justification. The kinship be-

[1]Penjon, A.: *Ibid.*, p. 117.

[2]For subjective proof of this read "Polly Baker's Defense" by Benjamin Franklin, also Dickens's Satire on American life in Martin Chuzzlewit.

tween humor and play not only suggests relationships between humor and freedom, which Penjon[1] has so well worked out, and between humor and æsthetics long ago indicated by Kant and recently treated by Lipps, but that mental activities long interpreted as play should be credited to humor. I have already indicated the survival-value of humor for superstition ; it doubtless performs a similar and larger function for play. It is suggested that a number of the so called plays of the higher mental processes named by Groos[2] are by nature humorous, the humor being expressed in forms of play. Humor, then, is an end in itself and has no practical interest in its object. *This fact constitutes its first differentia.*

I have already indicated that the sense of freedom is a constituent element in the humor process. Its consideration is next in order. To that end I submit some of the evidence as it had formed in my own mind before meeting with Penjon's extended account.

The family and guests are seated about the fireside enjoying the moments of silence. The only light is that of the glowing embers. A smouldering bit of bark suddenly flashes up and a smile plays over the faces of the silent group. The stroke of a sweet-toned clock or a sneeze or the dropping and rolling of a sewing thimble or of a ball of yarn produce under similar conditions the same effect. A group of boys are seated on the bank of a bathing pond apparently gazing at the water's glassy surface. Suddenly it is broken by huge drops of rain out of an apparently cloudless sky. The boys smile. The humor response in such cases is weak and simple. At such times consciousness is damped down to dreamy, pleasant processes under lax attention, and the mild humor results from the sudden, delicate, harmless stimulus piercing its surface tension, disrupting its feeble structure and thereby permitting it to move on in a more free and spontaneous fashion. But let the surface tension and structure of consciousness become toughened, cramped and tense by responding to routine or grave or hard conditions, and objects of little or no inherent humor will become excruciatingly humorous. "Snickerin' at nothin'" in the school room, giggling before strangers and company, especially at the table, the increasing intensity of annoying return waves of humor on solemn occasions are cases in point. Bain observes that in a court of justice or in an assembly of ordinary gravity a trifling incident causes laughter, and that the young are the greatest sufferers by the imposition of gravity and are the most disposed to break free from it. They entertain a mock solemnity for the intense delight of rebounding

[1]Penjon : *Ibid.*, p. 116.

[2]Groos, Karl : *Ibid.*, pp. 122-169.

from it, just as they toil up to the top of an eminence for the sake of the downward run. Members of college glee clubs inform me that they see humor in everything while on their vacation musical tours. Darwin records that the German soldiers before the siege of Paris, after strong excitement from exposure to extreme danger, were particularly apt to burst into laughter at the smallest joke. I have received testimony from eye witnesses of the San Francisco earthquake to the effect that for several days following the shock not only laughter but good nature and humor overflowed on slight provocation. The history of humorous literature discloses the fact that it is most prolific in those crises and changes in human affairs at which the consciousness of freedom breaks out. Martin[1] tells us that the parody was first introduced during the performance of Greek tragedies to relieve the audience from the intense mental strain. In the severe atmosphere of the king's court the court fool was an important adjunct. In reality his was the freest personality of the group, the king not excepted. King Lear and his fool furnish a most striking example in literature.

These considerations indicate an intimate kinship between the humor process and the sense of freedom. The real connection becomes apparent when the nature of the stimulus is taken into account. It has already been shown that the stimulus perverts and breaks up the mechanism and order about us. It appears as the only objective fact in our experience that dares to defy the world order with impunity, that can violate ruthlessly, without pain and without apology, the manifold human contrivances, social customs and relationships and thereby not only creates the sense of freedom, but also assures us that we may temporarily escape from the uniformities and mechanisms of life. The sense of freedom, once born through these temporary escapes from uniformity, has been objectified into the so-called principle of freedom. Any means that will lift the veil of law and social order and reveal freedom as an abiding reality, will produce pleasure. Play, art and the humor stimulus are such means. Play performs this function especially for the young, art for the trained and educated, but humor ministers impartially to all ages and classes. By its revelation of freedom, abundance of life, springs of spontaneity and possibilities of progress are made more manifest. So long as the present order of things is taken for granted, so long as present ways and laws are accepted as the only ways and laws, change and progress if any is accidental. The humor stimulus rends the veil of uniformities and bids us look behind the scene where

[1] Martin, A. S.: Parody, p. 1.

luck, chance, spontaneity and life operate. It is the uncertainties and not the certainties of life that give it zest and charm. Let the outcome of a game or contest become a "dead sure thing" and interest will flee away. We are rather chary of an over-scientific game in which luck and chance are supplanted by rigid rules. The humor stimulus gives glimpses of the world of uncertainties, of spontaneities and of life, and in so doing creates the sense of freedom of which the sense of humor is the obverse side. The sense of freedom is the second differentia, therefore, of humor.

The failure to see that the sense of freedom is a constituent part of the sense of humor is doubtless responsible for the "superiority" and "degradation" theories. The sense of power yields pleasure but not humor. The sense of power is wrapt up with obligations, practical interests and relationships, the humor stimulus does not make us aware of power. Incongruity, descending or otherwise, all disorders of time and space relations in our actions, customs and language, all mechanized living movements, all deliberate manipulation of the humor stimuli are only humorous when they excite the sense of freedom. If there is any genuine humor in the shouts of the victor, it is due to the sudden sense of freedom arising from the removal of the obstructions to victory. It would then appear that the multiplicity of humor theories may be resolved into the freedom theory. The theories hitherto advanced have been more a classification of humorous stimuli than explanations of humor as a mental process.

Origin. A cross section of our mental life shows first an aspect composed of hereditary factors (unlearned reactions), second a well defined aspect of acquired factors (learned reactions) composed of what the individual does for himself and what is done for him, and third an ill defined aspect that permeates the other two and in addition enjoys in part a separate existence of its own made up of unmechanized and elementary mental factors. One readily recognizes the second aspect as intelligence. Prof. Royce[1] calls it "docility." It may be termed mechanized mind in that it represents mind reduced to law and habit. Getting on in the world is dependent to a degree on a certain quantum of mechanized mind. Common usage employs such terms as habit, adjustment, adaptation, education, to designate such an equipment. Several processes are involved in its production, such as imitation, learning by "trial and error" and by "understanding." Of these methods those that make the most use of voluntary attention are the quickest in results and the most extravagant with mental en-

[1] Royce, Josiah: Outlines of Psychology, p. 38.

ergy; here it is that mental tension reaches its highest pitch. Relief comes in a variety of well known ways, humor, perhaps, being the most unique of the lot from the fact that it accomplishes its purpose with the least expenditure of energy and at a time, too, when the individual can ill afford to make sacrifices in the interest of recreation. Considering, then, the nature of humor as a mental process, and the nature of its stimulus, together with the conditions under which it appears, it seems highly probable that it emerged as a distinctive process from the states of *inattentive freedom* immediately preceded by states of *necessary attention*. It should be mentioned in this connection, that even with the sense of humor as a part of our conscious mechanism, its operation is decidedly influenced by the composition and organization of consciousness as affected by preoccupation, mood, temperament, beliefs and ideals. Miss Martin invaded this subtle field with experimental methods and came out with results well worthy of record.[1]

V.

Functions of Humor.

The psychical function of humor is to delicately cut the surface tension of consciousness and to increase the pliancy of its structure to the end that it may proceed on a new and strengthened basis. It "spells" the mind on an up-hill pull. Perhaps its largest function is to detach us from our world of good and evil, of loss and gain and enable us to see it in proper perspective. It frees us from vanity on the one hand and from pessimism on the other by keeping us larger than what we do and greater than what can happen to us.

The physiological function appears to be common knowledge, for certainly its supposed influence on adipose tissue has passed into a proverb. Kant cherished the belief that laughter had a beneficent effect on our digestive organs even down to our very entrails. Hecker advocates the idea that it relieves the anæmia of the brain induced by tickling.

Its biological function, in my judgment, is far more unique in mental economy than is its nature as a process. I have already called attention to the unmechanized aspect of mind, a matter more readily believed than easily proven. To adduce adequate evidence of the magnitude and the importance of this aspect of mind over the mechanized and hereditary portions would lead us too far afield. For the sake of a better appreciation of our problem, however, a few considerations on the point seem worth while. First, we register our belief in its existence by such expressions as mind growth, naïveté, self-activity, spon-

[1] Martin, L. J.: *Ibid.*, p. 64.

taneity, individual variation, genius and "mental initiative" (introduced by Prof. Royce), and by more remote terms like open mind, simple mind, youthful mind, unprejudiced mind. Second, many students of mind express themselves to the same effect. President G. Stanley Hall states that surely mind is as old as the body and certainly more complex: any lesser conception would indeed be a mean one. Prof. Shaler [1] expresses this view so clearly that I quote his words: "One of the results of the marvellously swift, absolutely free development of man's spirit is that there has as yet been insufficient time for it to become organized as are the conditions of the body, working in the instinctive manner in which the lower species do their complicated work through the fore-determined mental processes we term instincts. There are always gauges and standards for the endeavors in the mind as there are in the bodily frame. With us, however, all kinds of thinking are still a hurly-burly, a confusion, to which time and culture may possibly bring something like the order it has in the lower life, but which probably is as ever to remain in its present uncontrolled state." Third, biologists are generally agreed that the hand, the vocal organs and the cerebral cortex have undeveloped capacities far beyond present realization. Their possibilities are as yet unknown, and with the cortex its capacity appears to be infinite with only a small portion reduced to law and order. If we can so confidently assert unlimited capacity of these physical structures, then any lesser conception of mind is indeed an untenable one. It does not yet appear what we shall be, but there is general agreement that the immediate path of evolution will be spiritual rather than physical. And if spiritual, it must be confined to the free portion of mind, to those parts not yet close yoked to matter and frozen into habit. Of course there is universal consent that the mind should be mechanized to the extent of the needs of common life, of routine business, of the alphabets of learning and of the elements of culture, but anything beyond these points is inimical to both individual development and to racial evolution. Influences that tend to check mechanization and to incline the mind to grapple with the new and with the ideal prolong the possibilities of spiritual development. Humor and play are two such processes, with the honors in favor of humor. It stands guard at the dividing line between free and mechanized mind, to check mechanization and to preserve and fan the sparks of genius. And, like play, it keeps the individual young, projects the best in youth into adult life, sets metes and bounds to "do-

[1] Shaler, N. S.: The Measure of Greatness, *Atlantic Monthly*, Dec., 1906, p. 751.

cility'' and prevents the mental life of the race from hardening into instinctive and hereditary forces.

Humor is *par excellence* a social mental process, a distinctive feature of the social consciousness. It is, therefore, not completely described until that aspect is taken into account. Then, too, its bearing on creative art and the uses made of it in our social, political, commercial and industrial life call for more detailed attention than this paper can undertake.

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ANALOGY IN THE LANGUAGES OF PRIMITIVE PEOPLES.

By ALEXANDER F. CHAMBERLAIN.

One of the ways in which names are given to new and unfamiliar objects and things is from analogy with the old and familiar. An inspection of the vocabulary of our own English language shows how many times this has happened with us,—in various Aryan tongues "cat," "tiger," "lion," "cow," "dog," etc., have often given rise, through analogy, to other appellations of animals. And with primitive peoples this process is naturally more in evidence. This procedure is interesting psychologically both in relation to the laws of association and by reason of the fact that it occurs also so frequently in the language of children, to whom the naming of the unknown by analogy with the known seems to be as natural as it is to the savage and the barbarian. The examples here given are drawn from the language of the American Indians, whose value for the psychologist is just beginning to be appreciated.

Apple. This fruit seems to have taken the fancy of the Indians, and there are consequently many very interesting names for it, *e. g.*:

1. *Rose-hip.* The Kootenay name for apple is *gotlwa*, which properly designates the "hip" of the wild prairie rose (*Rosa pisocarpa*); the same word is now used also to designate apricot, peach, pear, tomato, etc. The English term "rose-apple" for rose-hip is an interesting instance of like analogy.

2. *Cranberry.* The Micmac *wenjoosoon* signifies, literally, "French (*wenjoo*) cranberry (*soon*)." The analogy between the cranberry and the apple is not at all confined to the American Indian. While on Cape Cod, a few years ago, the writer heard a lady, who had never seen cranberries growing before, exclaim, "Do you know what these cunning little apples are?"

Beet. In several Indian languages, the beet, with which the natives became acquainted after having known the turnip, was named after the latter. Thus in Ojibwa, *miskotchis*, "beet," signifies, literally, "red turnip."

Bottle. The word for bottle in the language of the Massachusetts (Natick) Indians, *quonoasq*, designates properly a "gourd." But in translating Matt. 9:17, Eliot used, for "in new bottles," *wuskishquadt*, derived from the radical *wiskq*, "pot, dish, or vessel."

Buckwheat. The Micmac name for buckwheat, *sooomancheejul*, signifies, literally, "little beechnuts," from the resemblance in shape.

Candy. In Micmac candy is called *upkoo*, which properly signifies "chewing gum," and, before that, "pitch" (of a conifer). Here the "chewing" has determined the name. The Kootenay Indians, of British Columbia, from another point of view, call candy *gaktletl k'koktci*, "variegated (striped) sugar."

Chocolate. This drink, itself of American Indian (ancient Mexican) origin, was, however, unknown to the northern tribes until introduced by the whites. Says Bishop Bompas (Dioc. of Mackenzie River, Lond., 1888, p. 97): "Chocolate is a favorite beverage with the sick, where it can be obtained, and it is looked upon as a medicine. The Indians universally give it the name of *ox blood*, because it was mistaken by them for the blood of the musk ox, when they first saw it used by the whites." The analogy is, perhaps, between the chocolate in cakes, or before using, and the coagulated or frozen blood of the musk-ox. In Ojibwa chocolate is called *miskwabo*, "red liquid." In Nipissing, Cuoq (Lex. Alg., Montreal, 1886, p. 231) defines *miskwabo* as "mélange de sang, de graisse et de farine,"—from this, as in Ojibwa, the name passed over to chocolate. In these Algonkian tongues there is a folk-thought and probably also an etymological identity between *misko* or *miskwa*, "red," and *miskwi*, "blood."

Cinnamon. The Ojibwa name for cinnamon is *miskwanagak*, literally "red-cedar bark," the analogy being determined by the crude form in which this spice first came to the attention of these Indians.

Cock of gun. The Ojibwa name is *obwâmens*, "little thigh," with which corresponds exactly in meaning the Micmac *aboogwŏkŭjeech*.

Cork. In Ojibwa and Nipissing cork is called *wajashkwedo*, which term properly designates "fungus or mushroom, on trees or in the ground." The analogy with fungus or mushroom is a very natural one.

Elephant. The elephant, as a captive in the parks and "zoos" of American cities, and as a prominent figure in circuses, became known to members of many American Indian tribes,—also by means of pictures in books, etc. The names conferred upon this animal indicate the diversity of the analogies suggested to the Indian mind. Mooney (Myths of the Cherokee, p. 265) tells us that the Cherokee call the elephant *kămămă ûtănâ*, "great butterfly," by reason of "the supposed resemblance of its long trunk and flapping ears to the proboscis and wings of that insect." One of the Ojibwa names for the elephant is *kĭtshi kokŭsh*, "great pig." The Micmac term for elephant, *bâstogobăiit*, signifies "a sea cow."

Fig. The Ojibwa name for fig is *gĭtshi shōmin*, "big raisin" (*shōmin* originally signified grape, then raisin). In Micmac the fig is called *tăpatatŭweemunŭl*, literally "potato fruit," or "potato balls," from the supposed resemblance.

Goat. The Micmac word for goat, *wenjooekuleboo*, signifies, literally, "French (*i. e.*, foreign) caribou."

Haycock. The Micmac word for haycock, *wees*, properly signifies "muskrat house," from the analogy of the shape.

Hinge. The literal meaning of the Micmac word for hinge, *memegeech*, is "butterfly," from the resemblance in shape of the outspread hinge to the butterfly with wings open.

Horse. The horse was extinct in North America long before the coming of the Europeans of the Columbian discovery, by whom it was reintroduced into this continent, and from whom, directly or indirectly, all Indian tribes possessing or having possessed it, have received this animal. Many aboriginal peoples, who did not adopt a foreign name for the strange animal, or create a new name by observing and describing, in the appellation given it, some of its peculiarities as they perceived them, named it from analogy with other creatures of their environment, which they thought it in some way or other resembled. Often the horse was named from analogy with the dog. Thus the Dakota *sunka wakan* means "mysterious (sacred) dog;" the Blackfoot *ponokamita* and the Kootenay *kitlkatlahatltsin* both signify "elk dog;" the Cree *mistatim* means "big dog." Another Indian tribe, the Shawnee, called the horse *mishewe*, "elk." The use of the dog by Indians as a beast of transportation probably led to the naming of the horse so often after it. The Dakota name indicates that the horse was looked upon sometimes as an animal of mystery, which fact also may have had to do with his having been named also after the elk, an animal that had several mysterious attributes among some Indian tribes, and was not infrequently a "medicine" animal, as was likewise the dog.

Lion. In many parts of North America the large, foreign Felidæ were named after the native animals they were thought to resemble. Thus the Ojibwa word for lion *mishibishi*, signifies, literally, "large wildcat or lynx" (*Lynx canadensis*); and in the Nipissing dialect *mishipishi* is applied to the lion, tiger, panther, leopard, etc.

Nutmeg. The Ojibwa word for nutmeg, *gitshi gawissakang*, signifies "big pepper." Possibly both shape and taste have shared in this designation.

Orange. This exotic fruit was often named by the Indians from analogy with already existing fruits. The Kootenay, living beyond the Rocky Mountains, and the Micmacs, dwelling on the shores of the Atlantic, speaking absolutely unrelated

languages, both named it after the hip of the wild rose. Kootenay *gowitlka gotlwa*, "orange," and Micmac *chikchowwegunech*, signify, the one, "large rose-hip," the other, "rose-hip."

Peacock. The Ojibwa word for peacock, *sasega misisse*, signifies, literally, "splendid (ornamented) turkey;" and another Ojibwa name is *oshawa misisse*, "green turkey."

Peach. One Ojibwa name for the peach is *mishipagasan*, "big plum," in analogy with the plums, cultivated and wild. A Kootenay term for peach is *aqkeitlmak*, which properly designated the fruit of the wild choke-cherry (*Prunus demissa*), the stone or pit of the fruit giving rise to the name.

Pear. The Micmac word for pear, *majeokteliguncheech*, means "little arrowhead," the name being given from the analogy in shape between the fruit and the blunt-headed arrows used for certain purposes by these Indians.

Pig. The Narragansett Indians called the European hog *ockqutchaun*, *i. e.*, "groundhog" (*Arctomys monax*). Concerning this word Roger William says, "a wild beast of a reddish hair, about the bigness of a pig, and rooting like a pig, from whence they give the name to all our swine." Trumbull derives the name (Natick Dict., p. 101) from âgushan, "he burrows," and makes the word cognate with modern Algonkian terms for "pig," Abnaki *agaskw*, Lenapé *goschgosch*, Micmac *koolkwes*, Ojibwa *kokush*, Cree *kokus*, etc. It has been said, however, that the *kokus* words are onomatopœic and refer to the habit of feeding of this animal.

Putty. The Ojibwa word for putty, *wassetchiganipigiw*, signifies, literally, "window pitch," while the Cree *wabamonabisko-passakwahigan* means "window glue."

Turkey. Although the wild turkey is native to Central America and Mexico, and before the advent of the Europeans was common from Florida to the Great Lakes, over the eastern half of the country, it, like the tame bird, was foreign to certain tribes of the Northwest, etc. Thus the Kootenay name for the turkey is *gowitlka t'ankuts*, literally "big grouse," the term being created from analogy with the ruffed grouse (*t'ankuts*). In like manner, the Blackfoot word for turkey, *omuxiketukki*, signifies, literally, "big prairie chicken."

Turnip. The Micmac word for turnip, *wenjooesugebun*, signifies, literally, French (foreign) ground-nut." The "ground-nut (*sugebun*)" was the *Apios tuberosa*, etc.

Vinegar. The Ojibwa word for vinegar, *shiwabo*, signifies, literally, "sour liquid," which is also the meaning of several other Indian names. The Kootenay term for vinegar, *kowistlahane*, means "it is sour."

Whiskey. The many ways in which intoxicating liquors of

European origin were thrust upon the Indians of North America, and the amount of these they were induced to consume, have evidently made a great impression on their minds, if one may judge from the many names applied to it by them, ranging from "fire-water" to "new milk." The Kootenay Indians, *e. g.*, have these names for whiskey: *Nipika wuo*, "spirit water;" *notluqane wuo*, "the water of the stranger;" *suyapi wuo*, "white man's water;" *wuo*, "water" (*i. e.*, "*the* water"). The Ojibwa *ishkote wabo*, "fire liquor," and its relatives in other Algonkian dialects, indicate the source of the colloquial "fire water." The Micmac *booktawich* is derived from *bookta*, "fire."

The examples cited above of analogical naming will serve to indicate the wealth of psychological material in the field of research. There are abundant data for an extended monograph dealing with the primitive tongues of America alone, to say nothing of those of other regions of the globe. It is curious to find an elephant and a hinge both termed a "butterfly." And "oxblood" for chocolate, "potato balls" for figs, "arrowhead" for pear, etc., reveal interesting turns of the aboriginal mind. For comparison with the corresponding phenomena of the language of children a dictionary of analogy-names in the speech of primitive people would be of great value. On this the present writer has made a beginning.

THE RACCOON: A STUDY IN ANIMAL INTELLIGENCE.

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INTRODUCTION.

The aim of comparative psychology is, in the end, a classification of minds according to the kind and complexity of their thinking. As the criterion for this thinking we are of course confined, in the case of animals, to what they do. We study animal behavior. We can observe what the animal does spontaneously in the wild (or in captivity) and how he reacts in experimental conditions. And nowhere is it more essential that

these two sorts of observation should go hand in hand. No experimenter can feel perfectly sure that his conditions of experimentation are such as to show the animal at his best without a most careful study of what the animal does or does not do in freedom and of its own accord; and no student of animals in the wild can be sure that his interpretation of what he sees is the true one unless the animal can be led to do the same sort of thing under fully known and controlled conditions. As Prof. Jastrow (17) remarks, "we can judge what animals think only by what they do, yet what they really do may be wholly different from what they apparently do."

Trustworthy observations of the life of raccoons in the wild are not easy to obtain, because, perhaps, of their nocturnal habits; and little that is definite and of psychological interest is to be found in literature. Such personal observations as the writer has been able to make upon a dozen or more of these animals in captivity will presently be described. The experimental studies which follow have been for the most part of the general type of those made by Thorndike, Kinnaman, and others, and furnish, it is believed, a tolerable basis for the relative ranking of the raccoon with reference to the animals studied by these experimenters.

It is perhaps fair to state, also, that the present study was begun in the early part of the year 1905, and was complete in its experimental part before the appearance of Prof. Cole's study of the same animal in the May number of the *Journal of Comparative Neurology and Psychology* for the current year. The two papers are nevertheless to a considerable extent supplementary of each other, and an effort has therefore been made to correlate the results and to point out differences.

ZOÖLOGY.

Geographical range and taxonomic relations. The raccoon inhabits the southern parts of the fur-bearing regions. Lewis and Clarke found the animal at the mouth of the Columbia River. The Hudson Bay Company purchased skins as far north as the Red River, latitude 50°. Dixon and Partlock obtained skins from the natives of Cook's River, latitude 60°. On the Atlantic coast, Newfoundland is the northern limit. The animal ranges southward over nearly all of North America and South America as far as Paraguay.

Matthew and Wortman from the latest study of tertiary remains place the immediate ancestor of the raccoon in the Oligocene period, and contrary to common opinion, make its affinity closer for the *Canidæ* than the *Ursidæ*.

Something of its general zoölogical kinship is shown by the

following summary of M. Watson's (37) study of the placentation of the raccoon:

1. *Procyon* agrees with all the other Carnivora in which the organ has hitherto been examined in the possession of a zonary or annular placenta, and also in the mode of interlocking of the fœtal and maternal portions of the placenta, and in the consequent deciduate character of that organ.

2. *Procyon* agrees with all the members of the plantigrade section, at the same time that it differs from those composing both the digitigrade and pinniped sections of the Carnivora, inasmuch as at one spot the placenta presents a gap or deficiency, at which spot the placental structure is imperfect.

3. *Procyon* agrees with *Canis* at the same time that it differs from *Felis* in the absence of a continuous layer of *decidua serotina* from the uterine surface of the detached placenta.

4. *Procyon* differs from every other carnivöre, in the possession of placental vessels possessed of a structure hitherto only met with in the placenta of *Cholœpus Hoffmanni* among the Edentates.

5. *Procyon* differs from every other carnivöre, in the non-possession of an umbilical vesicle.

6. *Procyon* differs from all carnivores of which the young have been hitherto examined, inasmuch as the fœtus is provided with a supernumerary cuticle or epitrichium, a structure which has only been met with in the young of certain members of other mammalian groups.

The length of the period of gestation is not accurately known. Its culmination varies through April and May. The mother gives birth to 4-6, usually in a hollow tree. In the Berlin Thiergarten in the spring of 1871, a mother brought forth five young. The young have been reared in captivity in America in several instances. At birth the young are small, about the size of a half grown rat. It is asserted that they are born blind like some other Carnivora.

General Observations.

In popular opinion, both among the Indians and whites, the raccoon has a high reputation for cunning and adroitness. Reports of the Bureau of American Ethnology (6, 7) have preserved for us many of the Indian folk-stories, in which the raccoon figures either as the chief actor of the story or else the subject of a parallel story in which the doings of some other animal of like cunning have been transferred to it. All these stories from whatever source have but one theme, namely, the subtility and cunning of the animal, which a short acquaintance will render as clearly apparent as it ever could have been to the Aborigines.

Food. Omniverousness has apparently had much to do with the development of the raccoon's hunting habits. He plunders the farmer's cornfield, he lifts the eggs from the woodpecker's nest, he gathers many kinds of nuts, grubs for roots, digs out turtles and frogs, goes berrying in the proper season, robs the chicken roosts, is a good fisherman and clam digger. All these and a hundred other activities combine to show the animal's great adaptability in the securing of a varied dietary. Confinement confirms the characteristics manifested in the wild. The raccoon seldom sulks when the table is spread. He never questions the cooking. He eats a good meal, and, given thirty minutes for refreshment in sleep, is ready for another as bountiful as the first. Fruit, bread, jellies, honey, sweetmeats, fish, molluscs, small crustaceans, rodents, and some green vegetables give sufficient variety for the selection of proper foods for feeding in captivity. Raccoons, however, adapt themselves to some one article of food, and as soon change to any other which may be forthcoming. I have fed them entirely on dog biscuit, then put them on a meat diet, changed to a varied diet, and then returned to the dog biscuit without much apparent loss of appetite, but the animal thrives best on a mixed diet. The particular conditions of feeding during experimentation will be spoken of later. (p.463.)

Physical Characters. The mobility of the fingers, with the sharp and partly retractile claws, which fit the hand for climbing as well as for other purposes; the bushy tail present as a balancing organ, and often slightly prehensile; the broad tuberculate molars, not thin and with cutting edges as in the purely cat tribe; the pointed and double edged canines; are all indicative of the physical resourcefulness of this animal, as well as its ability to hold its own against all comers of equal size. The raccoon climbs the bare steam pipes in the laboratory with as much ease as though they were the trees of the forest. He travels along the electric wire at the ceiling as if it were the branch of a tree and he on the under side of it. The prehensile and balancing characters of the tail appear whenever the animal attempts to climb, or stand on the hind feet in a place where the footing is uncertain, or when it is climbing a vertical surface, in which case the tail is used to steady the body in much the same manner that a woodpecker uses his while chipping the bark of the tree.

Significance of the Name Lotor (The Washer). The nicknames which the raccoon has received are closely associated with his observed habits in the wild. The Indian called him "the scratcher," "the oyster-eater." In Venezuela the Spanish local name is "Fox, wash thy hand." The name "washer" comes from the animal's habit of washing its food. Beckmann

gives an account of one which used to amuse himself by washing various odds and ends in a bucket of water. "An old pot handle, a snail shell, or anything of the sort would do, but the thing he loved the best was an empty bottle. Clasping it in his forepaws he would waddle slowly to the bucket with the bottle clasped close to his breast and then roll it and rinse it in the water. If any one ventured to disturb him, he was furious and threw himself upon his back, clinging so tightly to his beloved bottle that he could be lifted by it." *The Journal of Comparative Neurology*, Dec., 1892, p. 157, cites the case of a tame raccoon which was accustomed to carry his food across his cage to wash it, and if the particles were too small, so that he ate them up on the way to the water pan, he nevertheless continued to wash with nothing in his paws. Later, however, he failed to carry the smaller particles.[1]

The reason for the washing of the food has been variously assigned. By some it is attributed to a lack of saliva. Others say that since the raccoon obtains his food largely from the water, the washing must mean that the animal convinces itself by the washing that it has made a fresh catch. Still others think that the animal washes its food merely to clean or soften it, though the process turns out to be anything but a cleanly one with coons in captivity. Each of these explanations may and probably does have an inkling of the truth, but neither singly nor together, do they make clear the origin or the purpose of this interesting and puzzling, though long observed, habit. If water is not provided, the raccoon takes the food to the dry basin and there repeats his ancestral washing. A basin and water lacking, he sits on his haunches and rubs the food between his dry paws. If the key to the problem lies somewhere back in the long list of ancestral traits we may hope that some animal under observation will yet offer us the proper solution.

Dexterity in the use of paws. The cleverness with which the raccoon uses his paws is seen in the facility with which it will catch insects in their flight, an amusement which appeals to the young ones, and also in the marked ability to pick up minute morsels of food and carry them to its mouth. Ainsworth Davis (11) remarks that, "these peculiar powers of manipulation as regards the organs of prehension, by which the food is seized and carried to the mouth, are indicative of intelligence above the average in the animals in which they manifest themselves."

[1]Audubon remarks that he never saw his tame coon wash its food. In view of this most characteristic habit escaping the notice of the great naturalist, we can but remark, in passing, on the incompleteness of data which any single student may hope to secure from his own observations alone.

This dexterity is, however, in large degree a matter of practice. When raccoons first come in from the wild, and have gotten accustomed to take food from the keeper's hand, the paws are moved simultaneously to secure the morsel. Perfect co-ordination as to direction, in the movements either of both paws, or a single paw, is lacking. Through practice, however, the animals soon acquire the ability to use each fore paw independently, and are finally able to use one paw with greater quickness and accuracy than they formerly used the two. Burk's (8) exposition of the development of hand movements in the child would seem to throw light on this observation, for, as he remarks, "the progress in evolution of hand movements in the biologic scale has been from extreme fewness in number to infinite variety, from simplicity to complexity, from clumsy inaccuracy to precision, from simultaneous associations to those which constitute long series in sequence, from the general to the specialized. Féré shows in one of his works that the ability to move one hand without the other is small among the imbecile class. This tendency of the imbecile class to simultaneous movements suggests atavism since simultaniety is the dominating law of the fundamental movements and succession is the human characteristic of accessory movements. Simultaneous movements of the hand suggests reversion to the conditions when the hand was a fore limb." If, then, these conclusions are true we may here also find some justification for placing the raccoon above the average in the scale of intelligence.

Curiosity. While a perfected hand is without doubt a true index of intelligence, it is at best a physical and indirect one. A much more immediate and essential symptom is the exhibition of lively curiosity—in psychological terms, spontaneous attention and the instinct to investigate. Without it active intelligence is out of the question. The raccoon is an animal which displays this quality in a high degree. Its curiosity contributes to the development of its intelligence while at the same time it often becomes a source of serious lesson teaching. The animal would scarcely fall into the lure of the baited trap unless led on by its curiosity when once the scent of possible food has aroused it. The trapper takes advantage of this when he wraps a piece of tin foil around the trencher of the trap, which is then placed two or three inches under water, where it ripples a little, covering all but the foil with leaves or grass. The glittering foil prompts the coon to investigate.

Sometimes the raccoon manifests a knavery which leads to a just punishment. Groos (16) quotes from Beckmann the following account of a tame raccoon which was especially attached to a badger in the same enclosure. "On hot days the badger was accustomed to take his nap in the open air under the shade of

an alder. Then the mischievous coon found his opportunity, but as he feared the badger's bite he carefully kept his distance, satisfying himself with touching his victim softly in the rear at intervals. This was enough to keep the sleepy fellow awake and reduce him to despair. In vain he snapped at his tormentor; the wary coon trotted to the edge of the enclosure, and scarcely had the badger composed himself before he was at his old tricks. One day he was too severe with the badger, which went off growling and rolled into his hole. After awhile he put his head out on account of the heat and went to sleep thus intrenched. The coon saw that he could not expect much attention from his friend under these circumstances, and was about to set off for home when the badger suddenly awoke and stretched his narrow red mouth wide open. This so surprised our hero that he turned back to examine the rows of white teeth from every point of view. The badger continued immovable in the same position, and this excited the coon's curiosity to the highest pitch. At last he ventured to reach out and tap the badger's nose with his paw. In vain, there was no change. This behavior of his comrade was inexplicable, his impatience increased every moment, he must solve the riddle at any cost. He wandered about for awhile, apparently undecided how best to pursue the investigation, but reaching a decision at last he thrust his pointed snout in the badger's open jaws. The rest is not difficult to imagine. The jaws closed, and the raccoon caught in the trap, squirmed and floundered like a captive rat. After a mighty scuffling and tugging he at length succeeded in tearing his bleeding snout from the cruel teeth of the badger and fled precipitately. The lesson lasted a long time, and after it whenever he went near the badger's kennel he involuntarily put his paw over his nose." The above minutely detailed description shows how dominant the element of curiosity is, and in addition there appears a tenacity of memory plus something almost reflective, which found its expression in a quite fully developed new method of defense, namely, that of placing the paw above the snout when near the enemy. Raccoons, when not too wild, push their paws into all the pockets of the keeper which are accessible, and lift all movable parts of their cage and try to find out what is in or under them. Nothing escapes their notice in the long run. They therefore lend themselves readily to training or experimentation. Details illustrative of this last will follow in a later section.

Vocalizations. An interpretation of the vocalizations of the raccoon is possible only in terms of accompanying circumstance. The cry of the young for the mother is often so nearly like that of the human infant that unless one were accustomed to

hear it, it would easily be so mistaken. A low growl, like that of the bear in quality, warns off the intruder. This is also given when in possession of food and fearing its loss. When the coon springs forward to bite there is the accompanying snarl resembling in pitch and quality that of other members of the dog and bear family. A common call in the woods is in character a purr, which approaches very nearly in quality and carrying powers to the tremulous note of the tree frog. It lacks a little of the shrillness of the frog note, and rises in pitch when uttered by the young instead of the adult. When the mother is nursing her young, she gives forth a note which is almost a perfect imitation of the sound of a humming-bird's wings as it pauses before the flower. The two sounds are so nearly alike in character, that I was myself deceived many times before I was able to locate it in the cage rather than in the vines which grew in the rear. The mother's warning note in danger is almost inaudible. If one attempts to sound the letter *m* short and explosively with closed lips, at the same time allowing the air to be driven in short blasts through the nostrils, a very fair reproduction of the sound results. Although the note is very low, I have never seen a young one fail to recognize it even in the midst of the fiercest tussle of its play. A note quite frequently heard in captivity either while at play or, indeed when angered, can be very nearly reproduced by placing the lips in the position for whistling, and uttering the *oo* of boot followed by *f*—*oof*. This vocalization must also be given explosively. This and the note above require some practice to imitate perfectly. That the vocalizations of the mother possess great significance, although differing but slightly in quality, is shown by the experience with No. 3 when she was captured with her young. The mother was taken from the tree first and placed in a large box. When No. 5 was captured and pushed into the box with his mother he made a vicious attack upon her, but she simply gave out a low purring note and the young fellow immediately snuggled up to his mother and became quiet.

Fear. When the raccoon is afraid, it trembles, crouches into some corner, backs off, and frequently turns and runs. Sometimes the animal stands perfectly still with the head lowered and back hunched, looking at and following every movement in the direction of the cause of fright. The former attitude is shown in the animal at the left in Fi5. 7, Plate II, the latter position is shown in Fig. 4 of the same plate. Often a low vocalization or a diminutive grunt accompanies every movement. Sometimes a coon just in from the wild will try to cover its head and thus, ostrich like, render itself free from all danger. Fright is usually accompanied by a relaxation of the anal and

urinary muscles, resulting in defecation and discharge of urine.

Greed. That the raccoon is greedy goes without saying. An animal whose bare existence usually depends on getting all that can be secured is so instinctively. A raccoon will gather in one place all the food he can secure and sitting down upon it endeavor to keep all others away until the food is completely devoured. The method of dislodgment is to back in, push the would-be glutton from his spoil, and then reaching under the body pull the food to the new possessor. Sometimes there is a direct attack and scuffle. Food is not the only bone of contention. One animal will try to keep the others from the water basin. This activity, however, may change to a species of play. If the food is being given to the whole pack in small pieces, some will take their portion and stuff it in their mouths and return again and again until the mouth is filled to its utmost capacity. Often they will even throw away for the time being what is given them in order to be in the scuffle for the last rations. These activities are simply indications of the adaptation to wild conditions where periods of want follow hard upon those of satiety.

Play. The plays of the raccoon might be classified as: 1. Simple activity; 2. Feeding and fighting plays.

Plays of simple activity are those in which the animal plays for the most part by itself, as when it takes a small stick or wisp of straw, and rubbing it in the direction of its longer axis between the fore paws, raises its paws above its head during the rubbing until finally it falls or rolls over backwards. Catching a dangling rope with the teeth, or seizing a flying trapeze with all four paws and swinging on it, or going through gymnastics on a horizontal bar, also belong in this class. One of the raccoons, after jumping from the roof of the inner cage to a flying trapeze, swung for a few minutes and then fell some three or four feet to the floor of the cage, landing on her back. As if angered by the fall and giving the trapeze the credit for the mishap, she climbed to the top of the inner cage again and attempted to wrench and gnaw it from its fastenings. Here would seem to be the beginning of an association of immediate cause and effect. One of the young coons used to sit at night in front of the swing door to one of the sleeping boxes and raise it up and let it fall for half an hour at a time. I was never able to discover any particular reason for this activity, though there may be an element of pleasure in the rhythmic sound produced. A horse will sometimes move a carriage against its cramped wheel in such a way as to produce a rhythmic sound apparently for that purpose. Sometimes a coon will sit on its haunches and beat a tattoo

with its fore paws on the floor in front, with no other apparent purpose than its own amusement. Tipping over the water basin as soon as it was filled was indulged in by both old and young until I was compelled to put the water in an earthen jar too large and heavy to be tipped over. Catching flies from the walls of the sleeping boxes is a favorite amusement on sultry summer afternoons. Twice I noticed young ones in the act of sucking their paws after the manner of bears.

Among the plays which seem to be related to feeding and fighting, we find the raccoon dipping its paws into the water basin and then thrusting them while still wet into the face of a pursuer; also rubbing the dry and empty paws in the same fashion as when washing food in water, this is often resorted to as a form of amusement during the time between feeding periods. Sometimes one animal will take a piece of food and try to conceal it or run away with it, while others follow and try to secure it. This kind of play takes place when there is plenty of food and all have satisfied their appetite for the time being, since the food itself will often be left for some minutes before being eaten.

The fighting plays appear also in the tussle of the young with each other, old ones among themselves, or the mother with her young. If two animals begin a tussle, they usually stand off facing each other with head down, back humped, and paws extended in front. There are two or three preliminary advances and retreats and then comes the set-to, when, very much as in the "catch-as-catch-can" wrestling, they seize each other with the fore paws and twist and turn in the attempt to throw each other over backwards and thus expose the throat to attack. Once down there will be a playful use of teeth, accompanied by more or less vocalization, followed by a quick break-away and an immediate, or delayed renewal of the tussle. If the young ones begin such play with each other, it often happens that the old ones begin a similar match among themselves. This last may be an instance of imitation, and will receive consideration later. When one of the young ones attempted to hang from a low trapeze and have a good swing, another young one came along and, thrusting his nose into the gymnast's stomach pushed him to the floor and then took the place on the trapeze himself, throwing back his head and playfully growling at the discomfited fellow who usually took this as a signal to retaliate in a similar attack.

I gave them a rubber ball one day. At first they tried to eat it, but when they discovered that it would roll the play began in earnest. One would back off with the ball between his paws while another would try to secure possession of it. Its

attractiveness lasted but a short time, however, and after the first few days they never played with the ball again.

If the mother and young are approaching each other from opposite directions the mother will sometimes catch the hind foot of the young one just as she is passing and turn it over on its back with a quick flip, the young one then attempts to defend itself with its feet in air, or by curling up against the mother who tries to rub its stomach with her nose. I find this seizing by the hind foot while bearing off with the shoulders to be a very common method of fighting among mature coons. The raccoon also fights on its back, so we probably have here the beginnings of a proper training for future struggles where the life of the animal is at stake. Sometimes the young ones by themselves, but more often the mother would catch one by the tail, or hind foot, either with the paws or teeth, and drag it backwards across the cage. This usually resulted in a tussle, in which the victim on its back tried to seize the head and neck of the attacker with its fore paws and pull it down within reach of its jaws.

The study of Dr. Robinson (30) on ticklishness has evident bearing on this kind of play, and from him I quote:

"Not only every part of our physical frame, but every instinct and appetite, either is, or has been at some past stage of human history, necessary to secure the survival or prosperity of the race. The baring of the teeth, the defensive movements of the limbs; the attempts to protect regions from attack as neck, armpits, and groin are characteristic of tickling pursued to a vigorous outcome. We are dealing with but one type of ticklishuess, viz., that which is especially present in early life—when it is plainly associated with a natural desire or appetite which is intermittent, needing the subject to be in a receptive mood, and which is always associated with laughter and play. This form has a social significance, which the others, as irritability of the mucous membranes, on the palate and in the nostrils, or the palmer surfaces or soles of the feet, have not.

"The more ticklish regions of the body both in man and animals are chiefly the armpits and contiguous parts; the ribs, especially where they join the abdomen; the front and sides of the neck, especially just above the collar-bone; the upper and inner parts of the thigh, over the region known to anatomists as "Scarpa's Triangle"; and on the limbs, the parts behind the knee and in front of the elbow.

"Three points are plain: 1. All the young creatures which obviously take pleasure in being tickled—which have the appetite in a marked degree—are naturally playful, and appear to take a special delight in romps of a rough-and-tumble character, which are essentially mock battles. 2. The regions which are especially ticklish and most carefully defended in these games are those which, in a serious fight with formidable teeth and claws, would prove most vulnerable. 3. All these animals, with the exception of man, are armed in this way, and settle their differences by adroit use of such weapons.

"Hence, a young dog or ape which, in the innumerable sham fights of its youth learns to defend the axillæ where a single bite might sever the axillary artery; the neck with the carotids and windpipe just under the surface; the flanks, and borders of the ribs, where a

comparatively slight tear lays open the abdominal cavity; and the groin where the great femoral vessels lie close to the skin, would, without doubt, be vastly better equipped for the fierce combats for supremacy in after life than an animal which had not undergone the same elaborate training. Warfare becomes more and more a matter of education, tactics, and strategy, and less a matter of brute force, as the scale of intelligence is ascended. Innumerable feints and methods of attack appear which are countered by a series of guards equally elaborate. Strategy depends upon experience, adroitness, and adaptiveness and not upon inherent instincts. It must be learned; and a young animal which had not the advantage of an education derived from sham fights in early youth would be as helpless, when brought face to face with an experienced foe, as one of us who knew nothing of fisticuffs or sword-play would be, if he were pitted against a practiced pugilist or fencer."

One of the most interesting observations upon the play of these animals was made during the first week after I secured the mother and her three young ones. When no one was looking on they used to sally forth from the little inside sleeping boxes into the yard of the large cage. The mother was always leading and each little fellow followed with one of his fore paws on the hip of the fellow just ahead. This seemed like a sort of follow-the-leader game.

In rare instances there appeared activities which might be interpreted as having sexual significance. Such would be those where one animal seized the other by the thighs with the fore paws and held it thus for sometime, or simply dragged it about the cage after having thus seized it.

Hibernation. Attention has already been called to the ability of the raccoon to adapt itself to variations of diet. A study of its life during the first and second winters seems to point to a similar adaptability to prevailing differences of temparature. The characteristics of the hibernating period, as slight beating of the heart, apparent cessation of respiration, loss of fat accumulated during the summer and autumn in supplying the constant demand in the production of heat energy, the necessity of seclusion lest the shock of sudden waking with its heavy demand upon circulation and respiration should cause immediate death; these are all familiar to the student of the habits of mammals undergoing the profound sleep of the hibernating period. The raccoon, however, does not sleep as profoundly as the bear. The constant loss of moisture, compels it to come out of winter quarters and seek the water. In the wild when they come out they sometimes travel for a mile or more, either returning to their own den or turning in with another coon, with which they pass the remainder of the period.

During the first winter my animals went into hibernation in an apparently normal way. They used to come out about once in two weeks for water. At such times they seemed to be get-

ting weaker and weaker. Their actions were those of animals which had been in one position a long time, so that the trembling of the body, and tottering gait might have been due to a cramp from which they had but just found release. On coming out permanently in the spring, one of the animals was taken sick. She lost all her strength. If she attempted to climb or stand up on her hind legs, she would fall to the floor in a helpless condition. The enteric plug of the coon is not as large and hard, proportionately, as that of other hibernating animals, but this animal acted as if poisoned by the retention of the fæces and urine. Proceeding to treatment on the basis of this diagnosis she made a quick recovery after her relief from the disturbing cause.

During the first winter the cage was out of doors. During the second winter, since living in the city rendered it impracticable to keep the cage outside, it was placed in the basement of a stable. This was commodious and well lighted, and without artificial heat. The differences in temperature between inside and outside during the season were of but a few degrees, and yet none of the raccoons went into hibernation. Two others which came in, one about the middle of the winter and another almost at the end, went through the normal process of gradually waking. This failure to hibernate has thus far shown no determinate effect. In fact the physical condition of the animals seems higher since they have been able to avoid the usual depletion of the period. The lower latitudes of the geographical range of the raccoon offer conditions of such a character that hibernation is unnecessary, but the interesting feature of this observation was that so small differences of temperature seem to have been sufficient to cut out the period and habit altogether.

Disposal of excrement. Raccoons in the wild drop the fæces wherever they happen to be and leave them exposed. This is one of the means used by hunters for tracking them or determining their presence in a locality. It is also likely that from the observation of the fæces thus dropped, the Indians acquired sufficient knowledge of their feeding habits to attribute to them the conversations on the effects of certain wild fruits, which we find in the Indian folk-stories.

At first my animals in captivity followed the habit of the woods, exercising no selection of place for the deposit of the fæces. When confined in a small cage of two compartments, an upper and a lower, they soon made a choice, one of a corner in the lower compartment, the other of the entire upper compartment. When put into the larger cage, they gradually formed the habit of depositing behind the inner cage in a narrow but somewhat concealed passageway. When moved into

a still larger cage with other animals, where the floor was covered with sawdust, all soon selected a definite part of the floor and began covering the excrement. The seven animals which are now together in a still larger place of confinement, have two places within the area, and at one of the other of these they all, with but rare exception deposit, urinate, and cover.

Something similar, so far at least, as regards the constant use of a particular place is not infrequently to be observed in the case of other animals. I am not aware, however, that the taking on of the covering habit had been noticed. In any case the observation is a most interesting one. We have a stereotyped form of behavior which, if observed in its final steps alone, would unhesitatingly be pronounced instinctive, actually acquired in a comparatively short time and under observation. That it is a response to some special feature or features of the life in confinement can hardly be doubted, and the question is natural as to how far other stereotyped and seemingly instinctive forms of activity in these and other animals are likewise plastic and owe their seeming fixity to the fixity of the conditions in which the animals usually pass their lives. We may even ask the further question whether man's greater plasticity is not in large measure the reflexion of his complex and varying environment rather than a special endowment.

These questions are of course more difficult to answer than to ask and it is not our purpose here to try to answer them. Even the attempt to fix upon the special features of the life in captivity that are responsible for the change must be largely conjectural. The uniformity of place selected may have an element of imitation in it, to be discussed later, or may be the result of an association by which the odor of the excrement tends, when the time of excretion is near, to suggest the act. The disagreeable association of odure with no possibility of escape for an animal not accustomed to its presence may account for the covering which conceals what cannot be left behind and thus out of sight.

Temperament. Whoever has observed animals, either wild or tame, for any considerable time, sooner or later discovers that they, like the human animal, have widely differing temperaments, and manifest varying characteristics, which may depend in part on physical organization but find proximate cause in changes in weather conditions, food, or other disturbing factors not so readily classified. While it may be less possible even than with man to select distinctive physical marks of temperament, such as the color of the eyes, hair, and skin, temperature, character of the pulse beat and quality of the flesh, yet impetuousness of action, sluggishness, cruelty, ferocity, solitary or gregarious tendencies, moroseness, stupid-

ity, non-irritability, and such like, when observed, go far towards giving a more perfect understanding of animal life. Indeed, these temperamental differences are often as well defined as in the case of human individuals. Some animals are of the nervous, others of the phlegmatic, and still others of the bilious type, if we may be allowed to designate them thus for purposes of description. Those of the most purely nervous type are much more active, make many more movements in experimental work, and yet accomplish the task in the same or less time than their more slowly moving, accurate and phlegmatic fellows.

A blow with a stick may mean to one animal a never-to-be-forgotten injury, while to another it merely serves as a corrective. Raccoon No. 3, whose photograph appears in Figs. 4 and 11, and at the right of Fig. 7 in Plate II, has never ceased to remember a blow which was given in a thoughtless moment, when the master lost his temper. She is always suspicious, and makes use of every opportunity to spring at any person, for all alike are enemies. She will, however, stand up on a box at the opposite side of the room, or even in the middle of the floor and beg for food as if she were the most affectionate of all. (Fig. 11, Pl. II.) Go near and you are met with a growl, a spring and sharp teeth. (Fig. 7, Pl. II at the right.)

Figs. 3, 6, and 10, Pl. II, represent an animal at almost the opposite extreme. She has been punished for wrong doing but never resents it. She will come to you, sit on your knee, climb to your shoulder for food, and if she thrusts her pointed nose into your face, she never offers to bite, snarl, or intentionally scratch you. Fig. 1, is much of this same type, but being blind he must be touched gently, as he can only thus distinguish friend from foe. Fig. 2 shows an animal which was at the first timid and somewhat morose. For more than a year it was impossible to either coax or whip him into obedience; then suddenly, without any apparent cause, he changed entirely. He began to climb into the lap, to eat from the hand, and to do as was desired. He seems still to hold unpleasant memories of a stick which his master seldom carries now, and the passing of the stick may account for the absorption of the field by new and more pleasant associations.

A change of scene seems to affect all alike, save one. It usually takes about three weeks for them to settle comfortably into new quarters, and go about their experimental tasks. When they were moved into the university building I was not prepared to find them refusing to work even at their most familiar tests for more than ten weeks.[1] They even refused to

[1] A series of extraneous disturbances to which they were subjected during the earlier part of their stay in the university building had much to do with their long period of nervousness.

take their food from the hand, save one, as noted above. This is an old coon. Fresh changes may arise but she is never disturbed. She goes about as if all the new were old. I have never been able to get her full history, and so suspect that she may have been in captivity before, and possibly have escaped.

The field of observation in temperamental differences is a large one, but it is fertile with clues to all kinds of experimental problems, and its possible effects have, perhaps, been too little regarded by experimenters generally, especially when experiments have been made upon but few individuals.

Experiments.

Animals experimented upon. It is hardly possible to give more than an approximate estimation of the age of the animals which I have had and now have, in view of the fact that they were all secured from the wild and so fully grown as to put accurate figures out of the question. The figures are simply estimates based upon close observation by myself and others acquainted with the life of the raccoon in the wild. They are rough approximations, but are believed to be not far from the truth.

No.	Sex.	Approx. age.	Remarks.
1.	Female.	4½ yrs.	Trapped.
2.	Female.	4½ yrs.	Trapped,
3.	Female,	3 yrs.	Taken from tree with young.
4.	Male.	1½ yrs.	Young of No. 3.
5.	Male.	1½ yrs.	Young of No. 3. Died Feb., 1907.
6.	Male.	1½ yrs.	Young of No. 3.
7.	Female.	Age unknown, old.	Bought. Perhaps previously in captivity.
8.	Male.	2 yrs.	Obtained from Penn. Escaped, recap.
9.	Male.	2 yrs.	Obtained from Penn. Escaped.
10.	Male.	2 yrs.	Obtained from Penn. Escaped.
11.	Male.	3 yrs.	Trapped, escaped, recaptured, died.
12.	Female.	2½ yrs.	Trapped, died.

The ages given are either for the summer of 1907, or the age at death or escape. I have had to do with about equal numbers of each sex, and have not been able to determine that sex makes much difference in the matter of intelligence; it is rather the individual temperament and character which count.

Housing. During the three years which have thus far been given to a continuous observation of these animals, their quarters have been changed and enlarged as numbers increased and experimental conditions made greater demands for space. In the beginning, the first two animals were kept in an enclosure of chicken wire fastened to a wooden framework 6 ft. x 4 ft.

x 6 ft. The wire was reenforced by interwoven iron wire of No. 18 gauge. Inside this enclosure was a small two-storied closed cage in which the animals passed the nights and also hibernated during the first winter. In the spring the third animal which was trapped, No. 11 in the above list, escaped from this cage and thus made necessary the construction of larger and more secure housing. A cage 7 ft. square was constructed, with a wooden framework, which supported heavy iron screens of 1½ inch diagonal mesh, such as is commonly used in banking houses. The rear of this cage was shut in by a series of four two-storied sleeping boxes, so arranged as to be occupied singly or all thrown into communication. This offered facilities for the isolation of any particular animal during experimental periods, and at the same time made it possible to gratify the animals' propensity to crawl in and out through dark and light places. The third move was into an enclosure inside the University buildings. This is 14 ft. square, constructed on two sides of sheathing to a height of 7 ft., the remaining space above being shut in by heavy poultry wire of ½ inch mesh. The inside walls of the building form the other two sides of the enclosure. Two large windows look out on the street, which, however, is some distance away. The wire and the boxes and stands placed on the floor provide opportunity for exercise in climbing about.

Feeding. The sorts of food upon which the raccoon will thrive have already been mentioned (p. 450). In the matter of feeding three meals a day and regularity has been the rule. Bostock's (4) six days' feeding and one day's fasting has also been adopted. This equalizes somewhat the great differences between the conditions of food getting in the wild and in captivity. In so far as possible the times of experimentation have coincided with the feeding periods. In experiments like those in color discrimination, where variation in natural illumination was necessary, there was a departure from this rule. The ration has been fairly uniform. Neither a condition of satiety nor hunger has been sought, but such as seemed on close observation to be that of highest efficiency. It is somewhat significant that, after a period of work, the coons usually retired to the sleeping boxes and took a nap of greater or less duration. Whether this was an alternation of sleeping and eating or one of work and sleep is not clear. Probably all three factors entered in some degree.

Apparatus. In the experiments to be described, the food was placed inside a wooden box 15″ x 11″ x 12″, in the front of which was a door 6″ x 5″, which the animal was required to open in order to secure the food. (See Plate II, Fig. 5.) The

door was adjusted to open outward when it was once released by the locking device. The simple devices used were:

1. *A button.* This was so placed and adjusted that it must be thrust downward through an angle of about 40°. The button was placed at the upper right hand corner of the door during one series of trials, and at the upper left hand corner during a second series.
2. *A vertical gate hook.* This was placed at the middle of the door. It was adjusted to move to the right in one series of trials, and to the left in another series.
3. *A bolt.* This was of the common slide-bolt pattern. It was placed at the left of the door, and adjusted to slide to the left.
5. *A T-latch.* This was placed vertically at the middle of the door and adjusted to move to the right in one series of trials, and to the left in another series.
6. *A lift-latch.* This was placed at the right of the door, and adjusted to be moved through an angle of 90° in order to release the door.
7. *A plug.* This was placed on the top of the box, and so connected with a bolt inside the box that pulling the plug drew up the bolt and so released the door.
8. *A horizontal hook.* This was placed at the left of the door and had to be lifted in order to release the door. It was the same hook that had been used in the vertical position.
9. *A bear-down lever.* This was placed at the right end of the box, and adjusted to fasten the door on the inside. Lifting the inner end about an inch released the door.
10. *A push bar.* This was placed at the right end of the box. It was adjusted to fasten the door on the inside. A thrust of about three-quarters of an inch released the door.

Beside these simple locking devices, which were used singly, the door for certain experiments was held by two or three of such simple fastenings. These will be referred to as *Groups*. The elements of the groups were familiar to the animals from their use singly, and could, of course, be operated in any order. The groups were constituted as follows:

11. *Group I consisted of two buttons*, one at the upper right hand corner of the door and one at the upper left hand corner.
12. *Group II was the same as Group I with the vertical gate hook added* at the middle of the door between the buttons.

The *Combinations*, like the groups, were built up from the simple locking devices already familiar, but they differed from the groups in requiring that the elements should be operated, if at all, in a definite order.

13. *Combination I consisted of four locks*, a bear-down lever at the right end; a plug at the top; a button at the left of the door; and a vertical hook placed a little to the right of the middle of the door. The entire mechanism was so constructed that each simple lock, while a part of the combination, yet fastened the door by itself. The outside and inside views of this combination are given in Figs. 5 and 8, Plate II. When the lever numbered 1 was properly worked it fastened itself so that it could not be moved back again and refasten the door, and at the same time made it possible to pull up the plug 2. When the plug had been pulled, the button 3 could be turned; and

when the button had been turned, the hook 4 could be released, and the door would fly open.

14. *Combination II consisted also of four elements:* a push-bar at the left end; a bolt at the left of the door, to be thrust to the left; a button at the right of the door, to be thrust downward; and a kind of hook, known at the hardware dealers as an inside-blind catch, placed at the top of the door, to be thrust to the right. The internal character of the mechanism was similar to that of Combination I. In this combination, as in the other, the elements were so arranged as to prevent the accidental relocking of any one of them after it had been operated in its proper turn.

All the simple locking devices were set to move at between 300 grms. and 400 grms. It was not possible to adjust them accurately in the case of the combinations, on account of the combined lever system and the crudeness of the construction. In the combinations, therefore, there was much variation in the amount of force necessary to move the fastenings.

Method of Work. Food was placed inside the box, the door closed and fastened by whatever device was in use at the time. The closed box was then placed in the cage and the animal turned loose to investigate. No other incentive was given than curiosity and moderate appetite, possibly intensified by the smell of the food concealed in the box. At the first the box was not fastened to the floor, but it soon became necessary to fasten it, because of the rough handling it received unless so secured.

The times required for the working of the fastenings were taken with a stop-watch reading to fifths of seconds, but the curves presently to be considered were all plotted from the nearest readings in seconds. The time taken, included the entire period during which the animal was in contact with the locking device. If his attention was distracted note was taken of the same, and such and all known sources of error eliminated from the learning curves.

Each animal was given forty trials on each locking device. These forty trials were not always consecutive, because the animal often left the box after ten or twenty trials. Sometimes this was due to a satiety of food; at others it was due to lack of interest. A period of several hours or even an entire day might thus intervene at times between two consecutive trials.

The successful operation of the mechanism in one second was taken as the standard for perfection in the case of the simple locks. In the case of the combinations, the animal was considered up to standard when it worked the apparatus ten times in succession without error in the order or failure in muscular adjustment to the different locking devices. The times of such standard performances was uniformly about five seconds.

Results of Experiments.

Variations in the attack on locks. The tests indicate that each animal shows some individuality in the method of opening the locks, though different methods are employed at different times. Sometimes the variation appears in the way in which the animal approaches the box, and this often involved a characteristic method of attack; again in the order of working a group; and often in bringing into action not only the fore feet, but hind feet, nose and even the weight of the body. Age also makes a difference. Old coons work with reserve, directness, and accuracy; while the young ones, if they work at all, make a much larger but less regulated output of their energy. A few illustrations will make this matter clear.

When the button at the upper right hand corner of the door was first given to No. 1, she used to reach down the front of the box while standing on the top and thrust the button with the left paw. After a few trials she changed. Going around back of the box to the right end and reaching around the corner, she pulled the button towards her with the left paw. Sometimes she would come to the front of the box and thrust the button with the right paw, or with the teeth. Nos. 2, 3, 4 and 5 always went to the front of the box. No. 2 used her nose. No. 3 used her right paw and standing at the left thrust the button from her. No. 4 and No. 5 used both paws, and often teeth and paws.

In the case of the bolt at the left of the door, No. 1 has always worked it from the top of the box, by reaching down the front and thrusting the bolt to the left with the right paw. This method may have been borrowed from the position first assumed in the case of the button. No. 2 stands in front and a little to the right of the door and thrusts the bolt to the left with the left paw. No 3 stands at the left end of the box and pulls the bolt towards her with the right paw. Nos. 4 and 5 adopt at different times the method of No. 2 or that of No. 3. They have never worked from the top of the box thus far.

All five with practical uniformity now repeat the position and method finally fixed upon, whenever the same device is presented, even after intervening periods of days, weeks, or months. When Group II was given to No. 1, she used at the first to open the button at the left by standing at the left end of the box and pulling the button towards her with the right paw; then she would walk round behind the box to the right end and reaching the hook with her left paw pull both hook and button towards her. One variation of this method was to stand in front of the door and thrust the button on the left with the left paw, and the hook and button on the right with the nose. An-

other variation was, standing in front and placing the right paw on the right button, the left paw on the left button, and the nose on the hook, to open all at once. She had made use of the two paw method in the case of Group I, so that it was but a slight addition to use the nose on the hook. The reason for the use of the nose on the hook came from an earlier experience with it when it was the only lock in use. In attempting to open the door on the twenty-fourth trial of the vertical hook series, this animal caught one of her toes between the door and the hook. From that time she adopted the nose method and after more than a year, with no intervening trial she still persisted in it. This seems like in character to the action of the coon with the badger as related by Groos, and both show, in contrast to the repetition necessary to perfect the procedure in such things as opening the locks, that certain elements of behavior, probably those that are supported by strong instinctive tendencies, may be determined once for all by a single experience. The same thing appears also in No. 3's continued resentment of the blow already referred to. (p. 461.)

One of the most interesting and illuminating observations which I have been able to make as to the method by which complicated procedures are perfected is the following: One of the young coons, No. 5, was at work on the beardown lever at the right end of the box. It had just been preceded by the bolt at the left of the door. Although the bolt had been removed, leaving the front of the box smooth, No. 5 still devoted his attention to the place where the bolt had previously been, and nearly wore himself out trying to push something from the place where nothing was present. The previous association was too strong to be easily replaced. In the midst of his endeavors, during which he literally rolled over and over in front of the box, he assumed the position of standing on his head. While working in this position his right hind foot slipped off the top right hand corner of the box, and striking the lever pressed it down and opened the box. From the fourth to the eighth trials he would assume the up-side-down position, and work at the door until his foot slipped off the corner of the box, depressed the lever and so opened the door. His attention, however, was never shifted from the front of the box. Finally, in the midst of his gymnastics, his foot slipped off as usual, but did not strike the bar heavily enough to depress it and open the door, although it remained in contact with it. Distracted by this, he turned and using his fore paws thrust the lever down and opened the door. The next day he was working the lock by slipping his foot from the top of the box to the bar, and then turning about and using his fore paws. On the twenty-eigth trial of the series, he went directly to the bar and

opened the door by thrusting it down, but he still sat down on his haunches, placed his hind foot on the lever, and then assisted with the fore paws. It is fair to assume that in course of time something more easy than this awkward performance would have taken its place,—probably in the end the depressing of the lever with both fore paws, or even the right one alone; but the final steps in the short circuiting were cut off by No. 5's untimely death.

The above seems like a case of a stimulus having to beat out its path over an unblazed trail in a nerve wilderness. It is typical, however, of much of the learning of animals and indeed in a measure of all learning where the way is not opened up by hereditary predisposition or expert instruction. Repetition of imperfectly adapted movements brings about a final happy accident. Many rehearsals of the activities leading up to this follow. Continued practice, in ways not altogether clear as yet, leads to the gradual elimination of the extra movements; the unessential parts of the process are sloughed away and the essential solidified. The steps by which perfection is reached are very short and blindly taken, the new habit arising by slight successive modifications of one already in existence. Perception of the essential relations, if present at all, is dull and stupid to the last degree.

Restated from the beginning, it would seem that the smell of the food, intensified by the complex mental activity of curiosity, in some manner lets loose a surplus discharge of motor activity. This sooner or later leads by accident to an agreeable result and a consequent emphasis upon the nervous tract then in action. In this particular case that underlying the association between the position with the hind foot on the lever and the opening of the door. When this position alone happens to be insufficient the fore paws are brought to assist as the readiest means for that purpose—the members most responsive to any need of that character. So far our raccoon had gone.[1]

Burk (8) enumerates the "chief accessory lines of development that distinguish human movements as such, as: "(1) the breaking up of old bilateral and simultaneous tendencies, characteristic of central movements; (2) the growth of independent movements of smaller parts that previously only moved in conjunction with larger wholes; (3) the co-ordination of various series to form long and complex sequences as we finally find them illustrated by writing, sewing, piano-playing, etc.; (4) the development of precision and accuracy; and finally (5) the response of different movements to a great variety of dif-

[1] On this general matter see the paper of Dr. Meltzer, No. 22 of the bibliography at the end of this paper.

ferent stimuli." These all seem to find a ready illustration in the development of animal activity as well as in the child, although in the former case they may be placed on a somewhat lower level.

No. 1's experience with Combinations I and II, furnishes material of similar significance. As before stated, the locks of the combinations were not uniformly adjusted as to the force necessary to operate them (p. 465). Reference to Table I, shows the two chief sources of error, and the average number of errors per trial, in groups of ten. Thus 4.6 is the average number of errors in order, made in the first ten trials on Combination I, and 8.5 is the average number of errors of force applied in the first ten trials on Combination I. Lines 3 and 4 give similar results for Combination I, after a period of 286 days, with no intervening trial. Lines 5 and 6 give results for Combination II, as lines 1 and 2 give them for Combination I. The table seems to show that the memory of the order is more readily perfected, than that of the muscular adjustment required for each particular locking device. It would seem as though the order was something that could become definitely fixed while the muscular adjustment could proceed only to the point of pulling till something gave way. The reduction of errors in order is, perhaps, more uniform and less erratic, than that of errors of applied force.

TABLE I.

Relative proportions of errors in order and errors in force in working the combination locks.

Combination I.	1	Errors in order.	4.6	8.0	9.3	8.4	7.6	8.4	1.1	2.1	1.8	0.7	0.0	0.0	0.0	0.0
	2	Errors in appl'd force.	8.5	10.4	11.1	8.8	10.4	10.3	5.6	5.9	3.4	0.9	0.0	0.0	0.0	0.0
Combination I after 286 ds.	3	Errors in order.	3.5	0.7	1.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	Errors in appl'd force.	10.5	0.7	3.4	0.4	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Combination II.	5	Errors in order.	18.6	7.2	2.8	5.5	4.5	4.5	3.0	2.8	0.5	0.0	0.0	0.2	0.0	
	6	Errors in appl'd force.	24.1	24.2	7.3	7.3	4.6	5.0	3.0	2.8	1.7	0.0	0.4	0.5	0.0	

It is highly significant that the order was a constant quantity throughout the entire series of trials with each combination, while the force necessary to move any individual part of the combination was never quite the same. Proper co-ordination and development of precision and accuracy finally appear,

however, so that once the proper conditions are given, for the starting of a series of movements, they then follow with due force as well as in proper sequence.

In this connection No. 1's method of working the plug is also interesting. When the plug was first given, the method was to stand on the top of the box and pull out the plug with the teeth. The paws were often used to assist while in this position. After the first ten trials, she discovered that she could stand in front of the box and reach up and pull the plug out with her teeth. A few more trials changed the method to standing in front of the box and reaching up behind the plug and jerking it out with the left paw. After this final method became settled, the animal used to come to the front of the box sit up and place her paw behind the plug, look around in a seemingly careless fashion and jerk the plug out without giving any special attention to the process. It was almost as if she would think the device too easy to need anything more than a passing notice. Some such explanation may be plausible for different characters present in the learning curves, yet to be considered.

Cole (10) found with his raccoons, contrary to Thorndike's experience with the cats, that the animals never began work at parts of the box where fastenings had previously been, but went at once to the place of the fastening then in use. The raccoons "did not paw at the place where the loop had been nor did they claw at the loop or button when the door was open. I tried moving the loop from place to place in the boxes. Not once even did they claw where it had been; instead they attacked it at the new place with one direct movement." The trials of my coon No. 5 with the bear-down lever, during which he worked with so much energy at the place where the bolt had been, as described above, point in exactly the opposite way and lead me to think that Cole's results must be exceptional.

My No. 3, an old coon, the mother of No. 5, also behaved in a way to lead to a similar conclusion. After she had pushed back the vertical hook and the door had sprung open, she used to sit in front of the box, pull on the hook and then look inside to see if there was any more food. It was rather humorous to see her repeat this performance again and again. Later she dropped it and has never shown a like tendency since. Whether she gave evidence here of a perception of simple relations, as "this hook gives food," which later changed to "this hook and hole do not give food," may be open to question. When, however, the door was fastened and food placed inside, she never refused to work this lock. The above does not seem to differ much from the habits of the wild. The ani-

mal certainly senses certain conditions as indicative of food, and certain other as indicative of no food. The resulting associations persist and strengthen themselves in the first case. The latter cease to stimulate.

Old coons soon discover the difference in pulling at the long or the short arm of a lever, as in the button, while the young coon will work indifferently on the long or the short arm just as it happens to attack the device. It seems, sometimes, as if there were a kind of intelligent husbanding of energy, which shows itself with age. The tremendous output of energy in youth may be necessary to proper growth and the acquisition of experience, and possibly its numerous errors are thus intimately connected with the learning process.

In the working of Combination I, Raccoon No. 1 reached the arbitrary standard of ten perfect performances in trials ninety-eight to one hundred and seven. In the case of Combination II, the standard was reached in trials one hundred and twenty-five to one hundred and thirty-four. Since the first learning of the order, some variation has occurred in the animal's working of the locks in Combination I, all, however, in the direction of economy. The bear-down lever is now often opened by stepping on it with the hind foot as the animal mounts to the top of the box for the plug, and the button and hook on the front are usually opened by one movement of the right paw. This activity is similar in character to that of No. 5 already described on p. 467. No. 1 is shown in the act of doing this very thing in Fig. 9, Plate II. The tendency to "short circuit" is clear again in this instance.

In the tests with the combination locks an opportunity occurred for noticing the persistence of certain impressions and the signal importance of making no false steps in training. In the first fifteen trials on Combination I, the number of errors was comparatively few. During the next three trials, it was discovered, that while the combination was a perfect working mechanism if worked forward, an accidental reversal of the first element, the bear-down lever, would lock the box again. The animal did this very thing once, and after the device had been so arranged as to make its repetition impossible, more than fifty trials were necessary to bring the errors down again to the level of the first fifteen trials. "Fogging" an animal in this manner while under training will obviously play havoc with figures and render the results difficult of interpretation. Combination II had as one of its elements what is known at the hardware dealers as an inside-blind catch, with which the raccoon had had no previous experience. It proved, however, no more difficult than other parts of the combination. The animal seems to have attained to a sort of generalized behavior

with regard to fastenings which made small differences of little consequeuce.

After the two combinations had been learned perfectly, the raccoon would work them indifferently. If she were given one or two trials on Combination I and then it was replaced by Combination II, the animal never made the mistake of beginning on either apparatus as if it were the other. In view of the fact that the two combination boxes were not exactly of the same dimensions, and differed somewhat in color, there is little doubt that this difference sufficed to touch off in each case through the association centres the proper order and relation of movements for the particular combination presented.

The animal tends strongly to approach the boxes from one direction only. If this avenue of approach is blocked up, a new adjustment to the new condition will, of course, take place, but the old fastening from a new side presents about the same difficulty as a new fastening.

Time Required For Working the Several Devices.

The figures in Table II are typical of results obtained by this method of work with Raccoon No. 1. The figures are the times in seconds for the forty trials on each of thirteen simple locking devices and the two Groups. Similar tables for the other animals have been prepared but as they would present no significant variations other than those that will be mentioned as the exposition proceeds, it has been thought best not to publish them. The locks in the case of this animal were learned in the order here given.

The large figure 1's mark the record of the trial in which the animal worked the lock in one second for the first time. The medium figure 1's mark the record of the first trial in which the standard of one second was permanently reached.

The Learning Curves. In order to give a graphic representation of the nature of the learning process, as shown in the animal's experience with the locks, the following method was adopted, for which the writer is indebted to the kindly assistance of Prof. W. E. Story, of the Mathematical Department of Clark University. First, all trials affected by known sources of error were eliminated from each series. Then, since the working of the lock in one second had been determined upon as the standard of perfection, the number of trials necessary to attain this standard permanently was determined. Each series naturally gave a different number. Reference to Table II, for instance, shows that in the series for the bolt the standard was reached on the seventeenth trial, while in the case of the horizontal hook, the standard was reached on the fourth trial. The times of the trials were then plotted as

TABLE II.

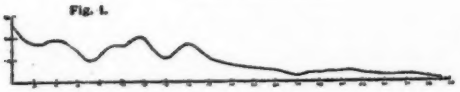
Time required for working the several devices in the case of Raccoon No. 1.

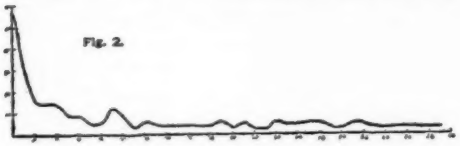
Trials.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Butt. R.	180	81	316	144	179	18	16	32	8	6	14	6	11	74	2	3	3	2	4	4	60	30	6	7	3	2	1	1	65	15	1	1	1	1	1	1	1	1	1	1
Butt. L.	24	46	40	9	2	35	14	16	6	34	2	21	6	4	3	2	9	1	4	9	4	6	10	4	6	11	9	6	1	5	3	2	4	6	2	1	1	1	1	1
V.Hook.	47	90	10	32	4	2	1	3	4	4	4	40	2	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bolt.	190	60	10	1	4	5	10	1	3	4	8	5	2	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
T-Latch L.	25	3	1	5	10	12	2	3	5	14	15	5	5	2	1	1	4	1	1	1	1	1	2	1	13	1	1	1	12	1	6	1	1	4	1	1	1	1	1	1
T-Latch R.	35	15	11	50	6	5	1	4	1	3	3	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ct-Latch.	1	1	12	8	2	1	7	1	1	1	1	1	1	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
H.Hook.	5	1	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Lever.	72	30	2	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Plug.	30	7	3	3	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F'sh.Bar.	264	234	40	15	6	17	1	11	1	1	9	2	3	1	3	3	3	3	1	1	2	1	2	1	1	2	1	1	2	1	1	1	1	1	1	1	1	1	1	1
Grp. I.	16	9	9	80	6	14	9	39	8	5	4	3	3	3	20	12	22	8	6	3	2	13	10	1	2	3	2	2	1	1	1	1	1	1	1	1	1	1	1	1
Grp. II.	20	1	2	5	6	2	2	3	2	2	4	9	3	15	1	2	2	2	1	1	1	1	9	1	6	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1

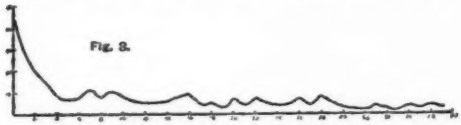
ordinates, and the number of trials from the first experience with the lock till the standard was reached as abscissas, as many equidistant points being taken along the horizontal axis as there were trials necessary to reach the standard. Thus in the case of the bolt mentioned above, the whole base line would be divided into sixteen equal intervals, giving with the point of origin seventeen points, while in the case of the horizontal hook, it would be divided into three equal intervals, giving four points. Proceeding in this manner, it was possible to superimpose graphically the curves for all the trials of an animal on all the locks. The average of all the times of the superimposed curves, for any single ordinate, therefore, determined a point in a generalized curve of learning which, as a whole, represents each animal's experience with all the locks. Several of the curves thus obtained are given in Plate I. Figs. 1-5 are the curves respectively of raccoons No. 3, 5, 4, 1, and 2. No explanation has yet been found for the elevations in curve No. 4 at intervals three and six.

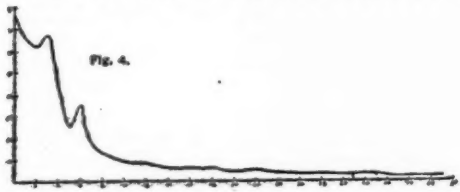
The curves, with perhaps the exception of the first, have the usual form of the learning curve. They agree in showing at first a more or less rapid falling off in the time required to work the different devices, followed by a gradually decreasing rate of progress as perfection is neared. The curves, however, fall into three groups of somewhat different types represented by Figs. 1 and 5; 2 and 3; and 4 respectively. Comparing Figs. 2 and 3, with Figs. 1, 4, and 5, it appears that the young animal learns more rapidly at first, having perhaps more to learn than the old, as shown by the sudden and long fall in their curves, Figs. 2 and 3, while the old animal profits more evidently by experience, as shown by the uniformly low level of the curves in Figs, 1, 4 and 5 after about the eighteenth or twentieth interval. The continued unevenness of the curves for the young animals is undoubtedly due to the fact that their learning is accompanied by fumbling and distraction of attention for a long time. The variation between Figs. 2 and 3 may be due to the fact that Fig. 3 represents the trials of an animal that is partially or totally blind, and thus is compelled to rely more definitely on touch and smell, and so loses the directness attendant on sight. Figs. 1 and 5, with their peculiar rise at about the twelfth interval, do not readily lend themselves to interpretation. This is especially true in view of Fig. 7 which represents the combined trials of the above four animals on one locking device. This device was not the first one given, but one chosen after each animal had had some experience with locks. This particular curve represents the tests on the vertical gate hook. It is typical, I think, when all things are taken into consideration. It presents, however, the

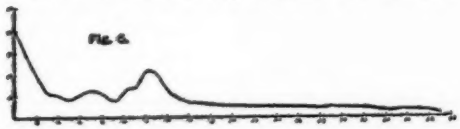
PLATE I.

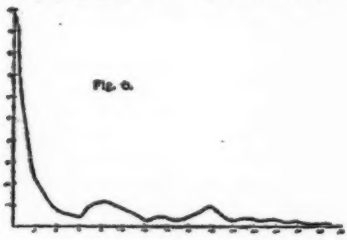


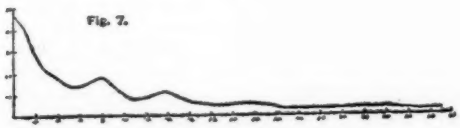












above mentioned peculiarities of Figs. 1 and 5, but has the same general character as all the curves. These rises may mean that after the first period of learning there is a short period of forgetting, or of inattention and indifferent effort. Familiarity with a given locking device would in such a case enter as a factor to increase the time. I have already described something of this sort in the trials of No. 1 on the plug (p. 470). We may have here perhaps the analogue of the "plateaus" which have received attention in the learning curves of human subjects. A comparison of Figs. 1, 5, and 4 would seem to indicate that there may be a temperamental factor in these elevations. The animals whose trials are represented by Figs. 1 and 5 are slower in all their activities than the animal whose trials are represented by Fig. 4.

Fig. 6 is interesting by way of comparison. This represents the series of thirty trials each on nine simple locking devices used by Kinnaman in his experiments with the monkeys, which were similar to those used by me with the raccoons under very nearly the same conditions. The figures are taken from his table and plotted on the same plan as the curves already considered for the raccoons. The general character of the curves is evidently the same for both animals. The value of the first experience seems, however, a little more evident in the case of the monkeys as shown by the steep descent of the curve. Indeed, the monkeys would seem to be a little less clever at the start. Elevations like those in Figs. 1 and 5 are to be noticed, but farther apart, falling on intervals eight and eighteen. The irregularity of the curve would suggest that the raccoon is less open to distraction than the monkey; and this might be considered by some as evidence of a lower level of intelligence on the ground that the coon works mechanically, but the opposite position might just as well be taken on the ground that the curve shows greater power of concentrated attention which is evidence of higher intelligence. My own position is one of uncertainty, since I have never had an opportunity to make general observations of the monkey's activities. These differences may also be of a temperamental character. It would seem evident on the face of the curves alone that the two animals stand fairly close together in the matter of learning to undo locking devices.

Combinations I and II were given to boys and girls to learn and the results of the trials were plotted on the same plan as the curves given above. Although the number of trials necessary to attain the standard fell inside of thirty, yet the character of the curve is the same as in the case of the animal.

The curves and the observations which they rest upon seem to justify the following general conclusions:

1. The learning curve for the raccoon follows closely the type of those found for other higher animals and for man.
2. The variations of method which appear in the animal's working of the locks and lead up finally to a permanent method seem to be simply the tendency to the formation of a "short circuit" by the elimination of useless movements, the permanent method being the shortest circuit for the raccoon.
3. There appears to be an increasing husbanding of energy, and profit by experience with increasing age.
4. There is an evident ability to respond to small differences in complex relations. How far the perception of such relations really enters is, however, for the present in doubt.

Experiments upon Association and Memory.

No one who has had to do with animals doubts that they remember, but the question as to the nature of the memorial processes is quite another matter. We have good reason to believe that the life of the animal lies very largely in the field of sense experience and an apparent recognition of relations may in any case prove to be nothing more than a reinstatement of the conditions under which the first association was formed.

During the tests with the raccoons on the simple locks, varying intervals of time broke the series of forty trials for each into groups of a less number. This was necessitated by the failing interest of the animal, but was readily accepted by the experimenter from a desire to discover if there was any well defined recollection from one period to another of the work done. It was soon evident, as had been expected, that the animal carried over from period to period some sort of an association, which resulted in a reduction of the time consumed in the working of the lock. It was then decided to give a crucial test to coon No. 1 using Combination I as the apparatus. The animal had been given preliminary trials with Combination II for a period of nine days, the intervals varying from seventeen to thirty-seven hours.

The results of these trials showed that memory is perfect for such short periods. The tests with Combination I extended over a period of 332 days, and the intervals varied from nine hours to 286 days, the latter period including the time of hibernation. The severity of the test is evident. Where the interval was short the memory was perfect. At the end of the long period there was a repetition of a series of trials similar in character to those made when the box was presented for the first time more than a year before. Only 24 trials were necessary to attain the perfect standard which had previously required 107 trials, and the times of these 24 trials were much shorter than the first 24 trials of the 107 trial series. It is thus

clear that while complex associations lapse somewhat with a long interval in which the original conditions are not present there is yet retained a pretty fair knowledge of what was at first presented. In the case of simple locking devices, however, after an interval of more than a year, with no intervening trial, different animals attack the lock with about the same accuracy, and with no greater variation in the time consumed than would appear in successive trials at the end of an original series in which the time had been reduced to its lowest factor. Simple associations would seem then to be quickly and permanently fixed.

It is extremely easy to underestimate the difference in associative responses that may follow the change in a single element of the situation presented to the animal. Animal No. 6, which manifested such fear and obstinacy when the keeper carried a certain stick, never seems to associate blows from the stick with the keeper himself. Nos. 3 and 8, which are always shut up at night in a small cage by themselves, had to be driven in at the first with blows from a stick. Now the association has been transferred to a mere movement of the box, at which signal they spring to the door and claw it open. No relation exists for them between keeper and box until the box has first been moved from the wall.

A study of the number of errors made in learning Combination I, brought out a tendency which had not shown itself before. If the animal left off a series of trials with a certain number of errors, and the intervening period was short, it would in the majority of cases begin the next series of tests with a *less* number of errors than it was making at the end of the preceding series. Two factors may have contributed to this result: 1. An unconscious elimination of errors during the interval of no practice; 2. A positive development of the right order, the 1, 2, 3, 4, thrusting itself into the foreground until at last it gained the ascendency.

The raccoon seems to give a high grade of attention to the work in hand. This is of importance in the development of its associations and their permanence. Perfection of the order of manipulation seems to come suddenly at last in spite of what we know from the curves and otherwise of the framework of associations which has been slowly set up in the midst of long continued and apparently aimless fumbling.

Experiments on Color Perception.

There is excellent experimental evidence that monkeys can discriminate colors as such. With raccoons the only experiments as yet reported are those of Cole (10), which he himself regards as inconclusive upon this point. The experiments

about to be described seem to me to indicate with a good deal of probability that the raccoon cannot discriminate colors as such, but depends on differences in brightness alone. His color blindness will perhaps seem less remarkable when it is recalled that the raccoon is the most nocturnal of all our mammals save the bats and flying squirrels, and that the work of Schultze and Ramon y Cajal has shown the retinas of nocturnal animals in general to be deficient in the retinal cones which seem to be essential for color vision.[1]

Apparatus. 1. A board 1″ x 10″ x 48″, had six holes bored on its centre line, 6″ apart. Six cylindrical tin cans, of uniform height and diameter, 4″ x 2½″, were fitted with plugs on the bottom, made to fit the holes in the base board, and thus prevent their being overturned. These cans were covered with Milton Bradley papers. Four were covered with the standard colors, red, blue, yellow, and green, the other two with neutral gray No. 1, and green gray No. 2.

2. The second piece of apparatus accomplished the same purpose as the first, by the use of six vertical slides, 6″ x 3″, with an opening 2″ x 1½″; cut at a uniform height from the base. These slides could be set in guides, in front of separate compartments 2½″ x 2½″ x 6″. The guides separated the slides about 2″ from each other. One set of slides was covered with the same papers as the cans of the first apparatus. A second set was covered with Hering's graded grays. This apparatus did not allow the animal to look into the container in which the food was placed.

The Milton Bradley papers were tested for brightness in a darkened room on a color mixer, using discs of black velvet and white cardboard as standard black and white. These determinations gave the approximate brightness value of red in terms of the white cardboard as 14°; green gray No. 2, 70°; blue, 82°; neut. gray No. 1, 140°; green, 167.5°; yellow, 240°.

The Hering grays of apparatus No. 2 were matched for brightness with the same apparatus as used above, but in diffused daylight. The black was given an approximate correction by use of Kirschmann's correction factor (*Wundt's Phil. Stud.*, Vol. 5, p. 300). These corrected numbers gave the series of approximate brightness values for the grays as 14.5°, 18°, 70°, 105.5°, 179.3°, and 360° respectively.

Method of Work. The two pieces of apparatus were used indifferently. The food was placed under one color, and when this color was moved to a new position, every other color was given a new position also. All changes in the apparatus were

[1] *Cf.* also Parinaud (27) La sensibilité de l'œil aux couleurs spectrals. The eye of the racoon also agrees with the results of Slonaker (31) for other mammals below the primates in its lack of a fovea.

made out of sight of the animal. When the apparatus was set, it was so placed as to give the animal about three feet of free space for approach. In this series of tests the trials were made also under widely varying conditions of illumination, viz., morning, afternoon, twilight, cloudy days, and at night by lamp light. The sense of smell was fogged by strong essences, essential oils, and other means used by trappers to disguise the trail.

Results of Experiments in Color Perception.

Of the several thousand tests made on different animals, I have given in Tables III, IV, and V, a series of tests covering color experiments with two animals, and brightness with one, coons Nos. 1 and 2. The results in Tables IV and V were obtained from the same animal, coon No. 2. Each vertical column gives the number of times in thirty trials in which the animal went directly and without hesitation to the color named. For further abbreviation, gray in Table V represents the sum of all the choices of brightnesses other than black. These tables are, I think, characteristic of all results obtained by further tests on the same or different animals. They show nothing more than a qualitative tendency. No tests involving Weber's law have yet been made.

TABLE III.

Food in Green.

Red.	11	7	9	5	7	6	6	3	2	3	7	2	4	9	8	7	2	7
Blue.	3	1	2	6	0	9	4	9	5	10	8	4	5	6	6	3	4	2
Gr. Gray No. 2.	6	2	3	2	1	7	8	4	2	4	4	5	8	5	3	2	2	7
Neut. Gray No. 1.	2	6	7	3	6	4	4	6	5	3	2	6	0	1	2	4	9	4
Yellow.	2	8	7	10	2	0	1	1	8	1	4	5	6	4	5	8	1	3
Green.	6	6	2	4	14	4	7	7	8	9	5	8	7	5	6	6	12	7

TABLE IV.

Food in Red.

Red.	7	9	5	7	12	13	12	7	14	7	7	8	6	13	10	12	19	15
Blue.	2	1	4	4	3	6	2	6	2	2	3	5	8	0	7	6	1	0
Gr. Gray No. 2.	2	3	2	4	0	1	2	4	5	2	1	1	2	5	9	7	1	1
Neut. Gray No. 1.	8	4	4	6	7	6	9	7	0	2	7	9	5	2	2	2	4	6
Yellow.	3	6	7	5	7	2	2	2	7	9	6	4	6	3	1	1	4	3
Green.	8	5	6	4	1	2	3	4	2	8	6	3	3	7	1	2	1	5

TABLE V.

Food in Black.

Black.	11	23	13	22	14	17	20	20	26	29	27	29	28	26	29
Gray.	19	7	17	8	16	13	10	10	4	1	3	1	2	4	1

Where color and brightness enter as simultaneous factors in a series of tests as in Tables III and IV some confusion results. A comparison of the results from all the tests on color and brightness, in percentages (Tables VI and VII), shows a decided variation in favor of brightness. These tables summarize all the color and brightness experiments thus far made. It will be recalled, of course, that in the experiments with the brightness and also with the colors the animal should have chosen rightly by mere chance in about 17% of the trials. That coon No. 2 did better than this is probably due to brightness discrimination.

TABLE VI.

Showing Percentage Choices of Colors.

	No. Tests.	Right Choices.	Upper Limit.	Lower Limit.
Coon No. 1.	960	20.5%	43.3%	7%
Coon No. 2.	1020	40.7%	63.3%	23%
Coon No. 3.	600	16.5%	26%	8%
Coon No. 5.	450	18.4%	30.5%	12.5%

TABLE VII.

Showing Percentage Choices of Brightness.

	No. Tests.	Right Choices.	Upper Limit.	Lower Limit.
Coon No. 1.	690	45.5%	90.3%	16.6%
Coon No. 2.	600	65%	96%	36%
Coon No. 3.	420	59.7%	93.3%	10%
Coon No. 5.	360	39.7%	90%	30%

Profiting by the experience in discrimination of brightness when associated with color, the animals attain as shown in Table VII, a high level of discrimination when brightness alone is present.

Cole's experiments seem to confirm the results here recorded. His black-white tests give values superior to those tabulated by me, he having obtained as high as 100% in a fifty trial series. He displayed his test-colors pairwise, however, thus offering but two possible choices, while in my experiments the number of possible choices was greatly increased in that all six slides were exposed simultaneously. Thus if the tendency to discriminate should appear in the case of the six exposures, it must thrust itself up through a comparatively thick stratum of disturbing elements. In the case of the red-green tests one of Cole's animals made as high as 91½% of right choices, and

another 83⅓%. He found, however, in this case as well as in that of the blue-yellow discrimination, that many more trials were necessary to attain successful discrimination than were necessary for a like discrimination of black-white.

A comparison of the Milton Bradley papers, used by Cole as well as by myself, according to the approximate determination of brightness given on p. 479, shows a brightness difference for blue-yellow, of 158°; red-green, 153.5°; black-white, 345.52°; black-yellow, 225.52°; black-blue, 67.52°; black-green, 153.02°. My own experiments show that in a rough way the raccoon can discriminate a difference of four degrees, and since all Cole's tests save one lie far outside this difference, I feel that his results give stronger confirmation of brightness discrimination than of color discrimination. Undoubtedly the raccoon can be taught to make what seem to be color discriminations, but it will really be a discrimination of brightness difference, which discrimination is essential to his wild life. He hardly needs color discrimination, since in the darkness of the night all colors fade to graded grays.

IMITATION.

When we approach the study of imitation in animal life we enter upon a field of controversy and of clashing definitions. It is necessary, therefore, that I state explicitly what I am going to mean by the word in the section that follows. I begin by excluding at the outset, all very accurate and nicely adjusted co-ordinate movements which bear the marks of inherited motor responses. If one of two puppies is thrown into the water and paddles his way to the shore while a second one looks on, we by no means have a case of imitation when the second puppy is likewise thrown in and also paddles ashore. And we can further exclude even those sorts of activity which are dictated by a strong gregarious instinct. We shall not in the present instance regard as imitation such actions as the general flight of a flock of crows when one or two of their number start off in alarm. For present purposes we shall regard as imitative those activities only which are individual in their nature and which are formed on the model of the acts of other animals. The action of the parrot which learns to talk, and the youth who goes to the Klondike in order, like others, to make his fortune, we shall regard as imitative. And we may distinguish two grades, illustrated tolerably by these two examples: a lower grade in which the imitation is executed for the satisfaction which it itself gives, and the other in which the imitation is undertaken with a view to the accomplishment of a definite result. The first of these is of an instinctive type and appears characteristically in many birds besides the par-

rot, in human infants, and possibly in the young of other species. The second is of a rational character, and when present is a mark of considerable psychic development. Here the issue seems fairly joined, for in raising the question—Does the animal on seeing a certain action performed by another desire to do the same in order that a certain result may follow?—we take our stand on the border line, howbeit somewhat broad, which separates rational from merely intelligent thinking.

In interpreting an action as imitative many investigators have placed great stress on what the animal *saw*, at the expense of what the animal *desired*. But even what an animal sees is by no means always certain, quite apart from physical imperfections in vision due to albinism, myopia, or nocturnal habits. Like Jastrow's "really do" and "apparently do," what an animal really sees and what it apparently sees may be widely different. Sufficient data from general observations are not yet forthcoming to certify the usual methods of testing imitation as fairly free from probable sources of error.

Citations will illustrate the point of contention. Berry (2) writes in regard to the rat:

"When put into the box he first tries to get out at the place nearest to the food, but not succeeding there he gradually works away from that spot until he has tried almost every spot in the box, or until he pulls the string that opens the door. Then his attention being attracted to the door by the sound it makes in opening, he runs to it and passes out to the food. When he is put back, take notice of what happens. Does he run at once to the string, pull it and open the door? By no means. He tries the door and finding it closed makes many random movements before starting in the general direction of the string. After nosing about in its vicinity for a time he finally succeeds in finding it and pulling it and thus escapes. It is not until he has got out many times that he goes at once to the string, pulls it and passes out, without making at first a number of random movements."

"These facts in regard to the way the rat learns to get out of a box are of vital importance in helping us to decide what we may reasonably expect from the rat in regard to imitation. If, when a rat by chance pulls the string and hears the door open, passes out and is fed, it cannot go directly to that string when put back, why should we expect a rat that has merely witnessed the performance to be able to do it. The rat that opens the door not only sees the string and sees his paw pull it, but he has in addition all the sensations that are connected with the movement of pulling the string, while the rat that looks on has only the visual sensation, no kinæsthetic sensations. It seems to me that we ought to be able to say *à priori*, in the light of these facts, that no ordinary rat would be able to open a door by pulling a string, simply from having seen another do it, without first making a number of random movements."

It is upon such a slender basis that Mr. Berry infers imitation. He lays great stress on the visual sensation as the chief factor in what he calls the final imitative act. It would seem as though he begs the whole question. If the act was imitation

in any true sense, just what we should expect to see would be the rat pulling the string with much fewer random movements, else in what particular does No. 2's method of learning to get out of the box differ from that employed by No. 1? Indeed, it would seem to require more than the "ordinary rat" to acquire the ability to free itself from the box, if it had no other tutelage than seeing another rat do the same thing. Small (32) expressly states, that he has never seen a case of what might be called inferential imitation. "By this I mean," he says, "merely the learning to do a thing by seeing another do it—the purposive association of another's action with a desired end."

Cole (10) again writes in regard to his raccoons:

> "After having had some six weeks of experience in distinguishing a black from a white card and in distinguishing complementary colors, each of the four raccoons developed a tendency to reach over the front board of the apparatus and claw up the colored cards. This tendency was encouraged and finally they would claw up the right (food) card and go to the high box to be fed, or, having clawed up the wrong (no food) card they would claw it down. So far as imitation is in question, the important point is that the raccoons did begin to do, or try to do what they had seen done by the experimenter. Before they began this they had learned to watch the cards and the movements of the trainer's hands very closely indeed. Therefore, the animals either imitated or else from their impatience to see the right card come up there sprang the idea that they themselves might make it come up. This, however, may be all there is in intelligent imitation."

To the present writer it seems that there is yet another alternative in this case. The behavior of the raccoons in clawing up the cards was due either to imitation, or to the idea that they themselves might make the proper card come up, or *it was an accidental result of the raccoons inveterate impulse to attack and manipulate anything that can be moved.* The animals had already associated the colored cards with the getting of food ; had earlier still been accustomed to get food by attacking some sort of fastening ; from this it is a short step—hardly a step at all—to attack the card holders. After having succeeded a few times in thus starting the train that leads to feeding, the activity would become stereotyped like the opening of boxes or any other. In any case we might expect imitation to occur, if at all, more readily when members of their own species furnish the models; and while these cases remain few and uncertain we may well entertain reserve as to those where the coon seems to imitate the experimenter.

As to the imitation of one coon by another, though I have been alert to discover it, I can report only doubtful or negative observations. Coon No. 3 sits up and begs for food (Fig. 11, Pl. II). She took up this activity of her own accord. I have simply strengthened the association of food and sitting up, by refusing food unless she does so. At the first No. 8 used to

sit up also. They took up the attitude together. Soon No. 8 dropped it and then picked it up again about three weeks later. Now he sits up regularly. No. 2 and No. 4 were taught to climb to the top of the stand in the middle of the floor of the cage for their food. No. 4 was taught to stand up on this stand for his food. He is blind so no visual element could have entered into his learning of the trick, but No. 2 which climbs to the stand with him, never stands up for food unless it is held directly above her head, when she will reach for it. No. 2 has had good opportunity to observe and therefore, copy, but no imitation has resulted. It might perhaps be thought that the climbing of the stand was the beginning of the imitative process, but No. 2 has been accustomed to climb to my shoulder for her food for more than a year. Climbing to the stand was therefore, simply a change of place. In the cases of No. 3 and No. 8, the position which they assume is one which is natural to the animal when suddenly startled. It then sits up to look for the cause of the disturbance. The position is also a preliminary fighting attitude. Both animals are timid and have not been long in captivity. It would seem, therefore, that we had here merely a partially transferred association from that of —danger, sit up—to that of—food, sit up.

No. 6 has taken to himself the habit of jumping for his food. This activity has been fostered, until he now jumps about 3 ft. high for his morsels. He is in the midst of the pack when they are being fed. No other animal has yet copied his method, although he rubs against them and jumps from their midst continually.

Six animals escaped from the cage in one night, by pulling down the wire netting in a corner at the ceiling. Three of these belonged to one litter; a mother and her two young were the second three. Once out of the cage, the first three jumped from the window to the ground a distance of some sixty feet. Two escaped, the injured one was recovered. The other group concealed themselves in one of the ventilating shafts in the wall of the building from which they were extricated with difficulty. Three other animals remained in the cage and made no apparent attempt to escape. The case of the six that escaped might be considered as indicating something of imitation, but I think it rather a case of the group or gregarious impulse to which I have already referred as of a different sort from the strict type of imitation under consideration. We know as yet so little of the importance to animals of litter and species odors, and of the general basis of gregariousness, that this factor must not be lost sight of.

Excluding such cases as this last and the doubtful ones of defecation and play already referred to (p. 456 p. 460) above, I

have seen nothing that I thought I was justified in regarding as a clear case of imitation, especially none of the inferential type. At the same time I am far from believing that imitations of the more instinctive type may not yet appear, especially in the case of young animals and of raccoons when free at night.

SUMMARY.

In summing up the results of the observations and experiments reported above the writer feels justified in making the following statements:

1. The common opinion of the adroitness and cunning of the raccoon is well founded and in agreement with his habits in the wild and with what may be inferred from his physical equipment and great adaptability.
2. The raccoon's instinctive powers of attention and curiosity are of a high order as compared with those of other animals.
3. The coons under observation developed a characteristic of depositing their excrement in a fixed place and covering it there, a form of behavior to which they are not accustomed in the wild.
4. The raccoons under observation showed wide differences in temperament—differences which are fundamental in the interpretation of all tests on their intelligence.
5. The experiments in which the animal opened various locking devices in order to obtain food showed a considerable variety of attack in the case of different animals and to a certain extent in the same animal at different stages. The perfecting of the power of undoing fastenings is accomplished by a slow series of small changes, consisting chiefly in the omission of unnecessary movements and the combination of those required.
6. The order of procedure in working the "combination" locks was perfected before the amount of effort necessary was fully learned.
7. Experience with former fastenings holds over in the case of new ones leading the animal at least in certain cases to begin his attack at the place on the surface of the food box where he has been accustomed to work. (This has been found by Thorndike in the case of cats, but denied by Cole in the case of raccoons.)
8. When an animal is forced to approach a familiar fastening from a new direction, it is often about as much bothered by it as by a new fastening. Nevertheless in course of time the animals seem to reach a sort of generalized manner of procedure which enables them to deal more promptly with any new fastening (not too different from others of their experience) than with the first few which they mastered.
9. The old animals seem to learn less rapidly at first than

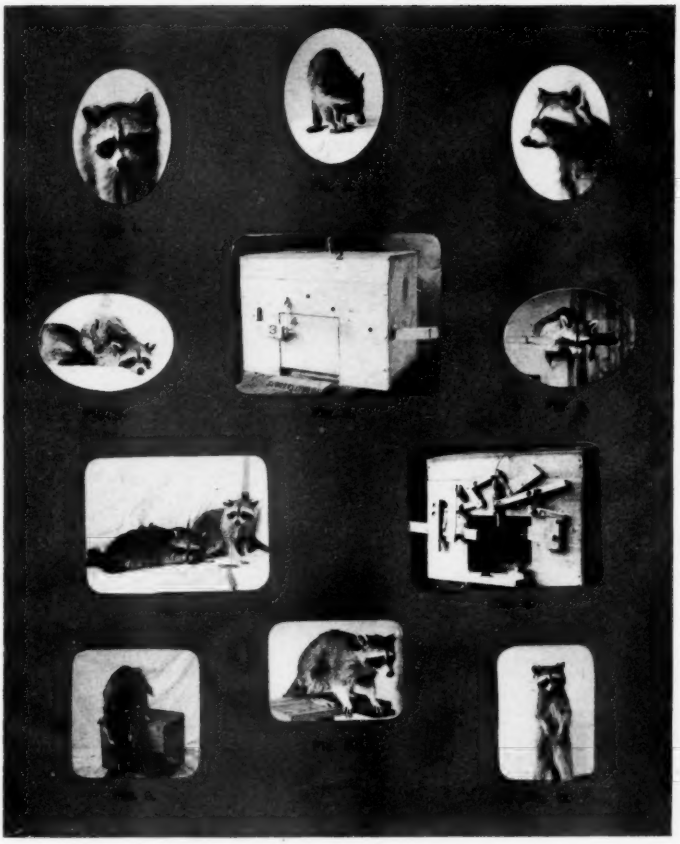


PLATE II.

Figs. 1, 2 and 3 show animals No. 4, 6 and 2, in characteristic attitudes of attention.

Fig. 4. No. 3 in the attitude of fear.

Fig. 5. Combination No. 1 closed and set, ready to be given to the animal.

Fig. 6. No. 2 in a characteristic resting or sleeping attitude.

Fig. 7. No. 8 at the left in the attitude of fear, and No. 2 at the right ready to fight.

Fig. 8. Internal mechanism of Combination No. 1, showing the interplay of locking devices.

Fig 9. No. 1 in the act of opening 3 and 4 in Combination No. 1.

Fig. 10. No. 2 in the attitude of attention.

Fig. 11. No. 3 begging for food.

the young, but profit more by their experience later, possibly because they are more attentive to the matter in hand and are more economical in the matter of effort and movement. These age differences appear in the learning curves.

10. The learning curves for the raccoons and Kinnaman's monkeys, so far as they permit a comparison of the animals, seem to show a nearly equal facility in learning to undo fastenings.

11. Test of the raccoon's powers of retention show that skill in undoing simple fastenings once learned remains practically undiminished for periods of no practice of more than a year. In the case of the "combination" locks the memory was imperfect after a period of 286 days, but the relearning was rapid, only 24 trials being necessary to gain a facility that originally required 107.

12. There was evidence in certain cases, where the intervals of practice were relatively short, of a gain in facility during the period of no practice, so that the animal began with fewer mistakes after the interval than before. This may, however, have been due to the beneficial effect of rest since the animal usually went to sleep at once after the tests.

13. The animals after practice adapt themselves correctly to comparatively small differences in the situation with which they are confronted.

14. The experiments on the discrimination of colors and brightness indicate with extreme probability that the raccoon is color blind. The raccoon's nocturnal manner of life would lead the experimenter to expect this result.

15. No certain cases of imitation of one raccoon by another were observed. The two or three doubtful cases were on the instinctive, not upon the rational level.

I wish here to thank Dr. E. C. Sanford for his kindly encouragement, suggestions and criticism during the entire period of observation. I owe acknowledgment also to Mr. J. H. Starr for assistance in the capture of the animals, and observation of the habits of animals in the wild which were fresh and first hand.

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MINOR STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF CLARK UNIVERSITY.

COMMUNICATED BY EDMUND C. SANFORD.

XIX. A PRELIMINARY STUDY OF THE PSYCHOLOGY OF REASONING.

BY WILLIS L. GARD.

An examination of the treatment of reasoning by most psychological writers reveals the fact that they have been largely influenced by the demands of formal logic. For many centuries the syllogism was regarded as the only form of reasoning. So recent a writer as John Stuart Mill enters a vigorous protest against the attempt, on the part of a few, to look on the syllogism as useless in reasoning. For him the syllogistic form is absolutely indispensable in testing the correctness of generalizations. But he admits that the syllogism is not a correct analysis of the psychic process of reasoning.

According to Mercier the regard for the syllogism, as a form of thought, has declined during the last thirty years. He affirms that the study of the reasoning processes should form a part of psychology; but he admits that in his discussion of the matter he has "bowed the knee in the House of Rimmon."

Lloyd Morgan declares that only those beings reason that are capable of "focusing the therefore," and implies that reasoning is a conscious attempt to justify our conclusions. It is an examination of the method by means of which we reach a conclusion. William James is still willing to say that "reasoning may be very well defined as the substitution of parts and their implications or consequences for wholes," though he treats the matter at some length descriptively.

Binet finds that there are three images involved in reasoning. The first calls forth the second by resemblance. The second suggests the third by contiguity; and this is all that there is in reasoning. Ribot would have us believe that "reason is only a means for control and proof."

George M. Stratton, however, writing in the *Psychological Review* for 1896 maintains that both logic and psychology have an interest in reasoning. But in the past the part that belongs to each science has not been very well made out and much confusion has resulted. Each has a different end in view and

employs a different method. In brief, Stratton holds, and rightly, that in logic, there is an attempt to justify the conclusion; in psychology there is an attempt to explain how the conclusion was reached.

These few and brief citations will serve to show how the discussion of reasoning has been influenced by formal logic even in the case of recent writers on the subject.

But little attention has been given to an experimental study of the question as yet. This may be explained in part by the fact that sensation and perception have furnished the experimentalist easier points of attack. Indeed, some have gone so far as to assert that reasoning is such a very complex process that we have little or no chance of ever being able to catch the mind in the act of pure reasoning. Groos, who has made some attempt in this direction, thinks that perhaps we shall be able to get most empirical material by noting the blunders of reasoning into which we fall. That reasoning is a difficult matter to deal with empirically is certainly evident to all, but it does not seem fair to place it among the impossible problems without further consideration.

The writer confesses himself more hopeful of a solution of these problems by the empirical method. Certain phases of reasoning may be observed in the solving of all problems and puzzles, and by introspection it ought to be possible to gain a fair account of the psychic process involved in the reasoning act. Believing that some information concerning reasoning could be obtained in this way, two series of simple experiments have been carried out.

The First Series of Experiments.

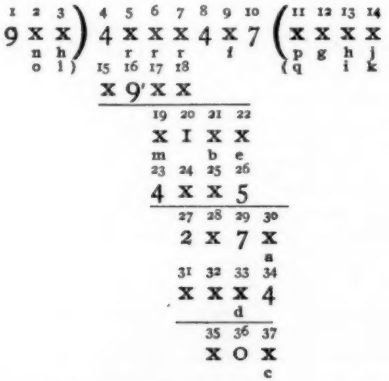
The first set of experiments was made with a problem in long division, found in the "puzzle column" of the *Congregationalist*.

The problem is as follows:

```
9 x x ) 4 x x x 4 x 7 ( x x x x
      x 9 x x  ___________
           x 1 x x
           4 x x 5
           -------
             2 x 7 x
             x x x 4
             -------
               x o x
```

It was the task of the subject to supply the proper figures for the crosses, and to take note, so far as he was able, of his mental processes while doing so. These introspections were recorded by an operator who was present during the solution. In this way it was possible to secure a somewhat full account of what went on in the mind during the solution. The problem was solved in this way by twenty-six persons.[1]

The following imaginary record is typical of the subjects, method of procedure except that the actual ones were less certain and direct. All notes and introspections also are here omitted. The procedure may be followed in the example below where the large figures are those of the original problem, the small figures above them are the numbers of the positions of the individual figures and x's numbered consecutively from left to right, and the letters below indicate the successive steps of the solution.



a. Inserted 7 in *30* from data given.
b. Inserted 4 in *21* from data given.
c. Obtained 3 in *37* by substraction.
d. Obtained 7 in *33* by substraction.
e. Obtained 2 in *22* by general rule of subtraction.
f. Inserted 2 in *9* from data found in fifth step.
g. Inserted 0 in *12* from data found in *21* and *22*.
h. Decided that *3* and *13* must be odd because *26* is odd.
i. Decided that *13* must be 5 because *23* is 4.
j. Decided that *14* must be 2 or 3 because of *27*.

[1]The writer wishes to express his obligation to Dr. Alvin Borgquist for the notes upon these solutions which were taken by him under the direction of Dr. Sanford.

k. Decided that *14* must be 2 because *3* is odd and *34* is even.

l. Decided that *3* must be 7 because it is the only odd number that multiplied by 2 and 5 gives 4 and 5 in units place in the product.

m. Decided that *19* must be 5 because *24* is greater than 1.

n. Decided that *2* should be 3 or 8 by alteratives.

o. Decided that *2* must be 8 by trial and error.

p. Decided that *11* must be 4 or 5 because of *4*.

q. Decided that *11* must be 5 by trial and error.

r. Inserted 9 8 6 in *5 6 7*.

A few other relations were used by a few of the subjects. The most important is the discovery that the 24th figure is 9.

The subjects tested in this series were of very various degrees of skill in introspection and it is quite clear that most were unable to do more than indicate the steps taken without entering upon a minute account of them. This is not at all remarkable, however, for there was apparently nothing but the associative rise of the required numbers in consciousness that could have been observed. The writer's own experience with the problem, confirmed by that of the best expert subjects that have been tested, seems to show that the reasoning processes involved are matters of simple associative recall. The particular feature of the problem which engages attention at the moment calls up associatively the digit required, or, when the case is more complicated, the several possibilities. *No trace appears of anything other than the familiar processes of association and apperception working under the special conditions of attention to the particular matter in hand.*

Of more importance perhaps than the elementary functions involved in reasoning, is the general method of attack upon the problem presented, the way in which clues are looked for and the adequacy with which they are apprehended when found. Here lies an immense field for individual differences. After tabulating the solutions of the problem, it was found possible to group them with regard to efficiency in three classes. The basis for the classification is the number of steps required to reach the solution and for this reason is arbitrary.

The best group consisted of seven solutions: 2 requiring fourteen steps; 1 fifteen; 1 sixteen; 1 seventeen and 2 eighteen. The medium group consisted of eleven solutions: 2 of nineteen steps; 3 of twenty; 2 of twenty-one; 3 of twenty-two and 1 of twenty-three. The poorest group consisted of eight solutions: 2 of twenty-four steps; 1 of twenty-five; 1 of twenty-six; 1 of twenty-eight; 1 of thirty-four; 1 of thirty-five and 1 of forty-nine.

The difference in the number of steps required to solve the

problem shows the individual differences. It is no doubt true that the variation in the number of steps may be explained in part by the difference in completeness with which the introspections were made. But some of the variation must certainly be attributed to psychical factors, such as methods of association, sagacity, and familiarity with the particular numerical relations involved. It is to be noted, however, that those most skilled in mathematics did not always reach the solution by the use of the fewest steps.

The different groups show different amounts of mental fumbling. There is, as might be expected, a close relation between the amount of fumbling and the number of steps required since the fumbling, or inability to see essential relations clearly, is the chief cause of the lengthening of the process of solution. When the successive steps of the solution are treated in groups of five the earlier groups show a higher percentage of fumbling than the later ones. There is much fumbling until a cue is found, which enables the subject to take a few definite steps. This, however, is soon exhausted and there often must then be another search with renewed fumbling. Only a few relations are simultaneously before the mind.

The method of attack seems to be influenced by habit. Five out of seven in the best group of subjects began with the first figure of the quotient. Seven out of eleven in the second group began with the same figure, while only three out of eight in the third group began with this figure. These facts show a rather strong tendency to follow the fixed habits in commencing the solution, and a certain advantage in so doing, or in the methodical habits of procedure that it indicates. They begin at the point where one would in solving an ordinary problem in division. It is in the formation of such habits that growing skill in mental operations consists.

The Second Series of Experiments.

In the second series of experiments the material was of the same nature as before, but the problems were much simpler. The form of each problem follows:

I.	II.	III.	IV.
x x 7) 2 0 7 7 (2	8	x) x 6 4	6 x
x x x 4	x	1 2 4	x
1 0 3	5		5 9 4
	1 8		

V.

$$\begin{array}{r} 76 \\ \underline{5x} \\ 17 \end{array}$$

VI.

$$x\,)\,\overline{x6x6}$$
$$1924$$

VII.

$$\begin{array}{r} x74 \\ 2x4 \\ \underline{35x} \\ x532 \end{array}$$

The task in these problems was the same as in the previous one. In all twenty persons have solved these seven problems and given a rather full account of the mental processes taking place during the solution. These subjects were all more or less experienced in introspection. An operator was present at the time the work was done and secured as full an account of the work as possible. The direct reports as to the detail of the processes was as meagre as before, but the simpler conditions permit more certain inferences as to its character. For an indication of the character of the data obtained, see pp. 499-501 below.

On examining the results, it was found possible to group the solutions according to the following scheme.

TABLE I.

Problems.	I.	II.	III.	IV.	V.	VI.	VII.
Sub-ject 1	B	A	E	B	C	D	C
" 2	B	A	E	B	C	E	C
" 3	A	A	D	A	A	D	C
" 4	B	A	E	B	C	E	C
" 5	B	A	E	B	C	D	C
" 6	B	A	E	B	C	D	C
" 7	B	C	D	B	C	D	C
" 8	B	C	E	B	C	E	C
" 9	B	A	E	A	A	E	C
" 10	B	A	E	A	C	E	C
" 11	A	A	D	A	C	D	C
" 12	B	A	D	A	A	D	C
" 13	B	A	E	A	C	E	A
" 14	B	A	E	A	C	E	C
" 15	B	A	E	A	C	E	C
" 16	A	A	D	B	A	E	C
" 17	A	A	E	A	A	E	C
" 18	B	C	E	B	C	E	C
" 19	B	C	E	B	C	D	C
" 20	B	A	E	A	A	D	A

Explanation of letters used in classifying the solutions.

Problem I.

A = The use of a general principle. This involved the subtracting of the remainder from the dividend and dividing by the quotient.

B = Trial and error method. The attempt to supply the missing figures by comparing the quotient and the divisor. The process was not wholly dependent on chance, but involved more or less uncertainty.

Problem II.

A = The use of a general principle. This consisted in adding 5 and 8, and subtracting the sum from 18.

C = The missing figure was supplied by mechanical sustitution.

Problem III.

D = The problem was solved by using one variable. The divisor was used as multiplier of the quotient. The divisor was changed until a product was obtained with a 6 in the ten's place.

E = The problem was solved by using two variable terms,—the divisor and the first figure in the dividend.

Problem IV.

A = The use of a general principle. This was done by dividing the product by the multiplicand.

B = The trial and error method. This consisted in assuming values for the missing figures and changing them until the conditions were satisfied.

Problem V.

A = The use of a general principle. The remainder was subtracted from the minuend.

C = Mechanical substitution as the result of familiarity with the relations involved.

Problem VI.

D = The use of one variable.

E = The use of two variables.

Problem VII.

A = General principle used. See A under the second problem.

C = Mechanical substitution. See C above.

Methods *D* and *E* stand between methods *A* and *B*, in that they are guided by general principles though not such as can be so easily formulated and brought definitely to consciousness, and even in the *B* method the trials are not wholly at random.

Summary of the table.

Problem I.	Problem II.	Problem III.	Problem IV.
A = 4	A = 16	E = 15	A = 10
B = 16	C = 4	D = 5	B = 10

Problem V.	Problem VI.	Problem VII.
A = 6	D = 9	A = 2
C = 14	E = 11	C = 18

Problem I was to many rather difficult, and the results show a very strong tendency to use the "trial and error" method in the solution. This method was persisted in in spite of the fact that a very direct method was plainly indicated by the data given. The form of the problem seems to have suggested old associations and the subject at once began the search for the cue by using the quotient as one factor. It was difficult for most to change this first impression and often a struggle resulted. Those who applied the general principle did so at once and the result followed immediately.

The second problem was an easy one and these subjects show

a strong tendency to use a general principle in its solution. The solution followed almost as soon as the problem was perceived, but fifteen out of twenty testified that a solution was reached by applying a general principle. Possibly, however, the general principle may have been appealed to for jnstification of the result to themselves rather than in reaching the solution.

The third problem was more difficult, but there was an increase in the number of those who attacked the problem in the most direct way. In this problem and in the sixth one the most direct method was to use but one variable quantity. It is noted that there is an increase in the number of those who saw the most direct method of solving this problem. This may be due to a "warming up" to the work, to the influence of practice, or to the refreshing the mind for the old numerical relation.

The fourth problem was selected because it presented conditions of medium difficulty. The subjects fall into two equal classes. Those who used the *A* method applied the most general principle possible to its solution. Those who used the *B* method followed the "trial and error method." They varied the two missing figures until a set was found that satisfied the conditions.

In the fifth problem fourteen out of twenty found themselves applying a general principle of subtraction. They subtracted the remainder from the minuend and thus obtained the missing figure in the subtrahend. Some felt sure, however, that the missing figure was supplied almost spontaneously on seeing the problem.

The seventh problem contained very simple conditions and the results show that eighteen out of twenty saw the missing figures instantly on seeing the given figures in each column. These eighteen assert that there was no adding of the given figures and subtracting this sum from the grand total. The associations were so ready that they resulted at once on seeing the conditions.

Some General Observations Made by the Subjects.

One subject reports that a solution which starts off with success but breaks down at a point near the end, produces something like a mental "cramp." The mind is reluctant to abandon a course that has almost resulted in success. There is a tendency to believe that the data are wrong rather than admit there is an error in the computation. There seems to be a poverty of possible chances, and a tendency to force a solution along lines that give an initial success. The same person remarks that he tries to solve puzzles by trying the same plan time after time. An initial success which proves to be partial

makes it all the more difficult to modify a plan of attack, while initial failure leads more readily to new plans.

The fourth problem is as follows:

$$\begin{array}{r} 6\,x \\ \times\quad x \\ \hline 594 \end{array}$$

One subject noticed that the fact that a six was placed in ten's position in the multiplicand caused him to conclude that the missing figure in the multiplicand cannot be a six. The mere presence of the six had excluded the possibility of the missing figure being a six. He had a feeling that the missing numbers must be eight and eight, and it was difficult to drive himself into an admission that the missing numbers must be nine and six. The thought of putting another six in the multiplicand was certainly inhibited by the presence of one six already in the multiplicand. Several others noticed that they were led to believe that the missing figures in the multiplicand and multiplier were alike. The fact that each was represented by the same sign seemed to suggest this to them, although they had been told at the outset that a cross may represent any one of the digits.

One subject reports that the large product in the fourth problem suggested a large digit for the multiplier. The subject was conscious that the 594 was very near to 600, and because of a tendency to work with ten as a unit the multiplier was seen to be 9.

Another testifies that the missing figures in the fourth problem were kept in the foreground, while the 6 and 59 were in the background.

Another reports that he tried 6 in the multiplier of the fourth problem because he felt that the multiplier must be a reasonably large number. The six was taken before he had considered all the data, and the conclusion seems to have been based on a vague consciousness of the relations existing between the given factors.

One person in solving the third problem asserts that he did not try a large number in the divisor at first, for the product obtained by multiplying the divisor by the quotient must not contain more than three figures. He must keep within this limit.

It may be suggested that the figures with which the subject began give a fair indication as to his general feeling regarding the numbers to be supplied.

The following will illustrate the nature of the data gathered:

The A Method in the First Problem.

The subject first saw that the second line contains blanks and at once resorted to a general rule of subtraction— "Given the minuend and the remainder to find the subtrahend." As soon as the subtraction was completed he knew that the second line was twice the divisor. This division gave the required divisor.

The B Method in the First Problem.

$$\begin{array}{r} {\scriptstyle 1\ 2\ 3}\\ x\,x\,7 \end{array}\Big)\begin{array}{r} {\scriptstyle 4\ 5\ 6\ 7}\\ 2\,0\,7\,7 \end{array}\Big(\begin{array}{l} {\scriptstyle 8}\\ 2 \end{array}$$

$$\begin{array}{r} {\scriptstyle 9\ 10\ 11\ 12}\\ x\,x\,x\,4 \end{array}$$

$$\begin{array}{r} {\scriptstyle 13\ 14\ 15}\\ 1\,0\,3 \end{array}$$

The first idea was that the figure in position (1) may be 1 or 9. But it was soon decided to reject 9 on the account of 2 in position (4). At this point it was discovered that 2 was the entire quotient. The problem was begun anew by multiplying seven in position (3) by 2 in position (8). Since the figure in position (11) is 7, the figure in position (2) must be such that when multiplied by 2 will equal a number ending in 6 for a product. This will make the figure in position (2) equal 3. Then the first in the divisor is a 9 after all. Then 9, 8, 7, 6, 5 and 4 were tried as the second figure of the divisor, but all were rejected and 3 was declared once more to be the correct number for the position. But this does not work. At this point the subject was forced to repeat the series 3, 4, 5, 6, 7, 8 for position (2). By this repetition 8 was found to be the correct figure. In the first trial 8 seems to have been skipped in some way.

The A Method in the Second Problem.

The subject saw at once that the process was addition. Immediately he saw $8 + 5 = 13$. $18 - 13 = 5$. The first step came without hesitation and then there was a slight delay in the subtraction process, due perhaps to the verifying of the results.

The C Method in the Second Problem.

The sum was seen to be 18. $5 + 8 = 13$, and at this point saw that the number required equaled 5. He did not say "13 from 18" to get his 5.

The D Method in the Third Problem.

The subject began with 24 in the quotient and the six in the dividend. He noted that the first multiple of 24 containing 6 in the ten's place was 7. $7 \times 24 = 168$. Having done this he concluded that the divisor was 7. The entire dividend was then obtained by multiplying 124 by 7. It required only a few seconds to find the blanks, and the subject began at once his solution with 24 and 6 as the clew to the solution.

The E Method in the Third Problem.

The subject began by saying x into x will equal 1. But this told him nothing. He then looked at 6 in the dividend and 12 in the quotient and repeated $12 = 2 \times 6$. He dropped this clue as it did not amount to

$$\begin{array}{r} x\,6\,x\\ 1\,2\,4 \end{array}\Big)\,x$$

anything. He then saw that six in the dividend was the clew. 2 into 6 equals 3. From this he decided that 3 was the divisor and three was the first figure in the dividend. Here he was balked. He then tried 4 in the divisor. Impossible to say just what was done here. He lingered over this point for some time. He then multiplied 124 by 2 to see if it would not help; but it would not do. He had already rejected 3 from the divisor. He then returned to the divisor and tried 2 once more forgetting that it had already been rejected. He then tried dividing 26 by 2 with 13 as the quotient. This did not help. He tries 3 in the divisor once more. "Must have felt that I made a mistake before." He then realized that he was trying each digit in succession. He now tried 4 but soon rejected it. He now felt that he did not want to follow up the scale any further. But at the same time this would give the correct result. He now returns to 124 in the quotient and multiplies it by 4. He was now ready to try anything to get a change of attack. He returned to 3 for the divisor once more, being influenced by the 2 in the quotient and the 6 in the dividend, although this had been worked out and the 3 rejected from the divisor. He now saw that 124 in the quotient would have to be multiplied by something so as to have 6 in the ten's place as shown by the 6 in the dividend. He then tried 5, 6 and seven as multipliers. 7 gave the desired result.

The A Method in the Fourth Problem.

As soon as the subject saw the data, he divided 594 by 6. This gave 9 for the multiplier. Then $9 \times 60 = 540$. $594 - 540 = 54$. 9 into 54 $= 6$, the missing figure in the multiplicand.

The B Method in the Fourth Problem.

The subject's first thought was that the missing figures must be alike and that 8×8 would satisfy the conditions. He had a feeling that the missing figure in the multiplicand must not be 6, for the 6 already in the multiplicand closed the door against the possibility of another 6 in the multiplicand. But 8×8 gave 64. This would not do. With 9 in the multiplier and six in the multiplicand the product would be 54. This showed that he must have 5 to carry. He then thought of 10×6. But he could scarcely get away from the 8×8. He was then pushed into $9 \times 6 = 54$. The 6 certainly inhibited the placing another 6 in the multiplicand.

The A Method in the Fifth Problem.

The subject saw at once that the process was subtraction. $76 - 17 = 59$. The method was suggested just as soon as he saw the data.

The C Method in the Fifth Problem.

The subject sought for a number which when subtracted from 16 would give 7 for a remainder. He saw that the missing number must be larger than 6 to give 7 for a remainder. He then added 10 to 6. Then he sought for a number which subtracted from 16 would equal 7. This number was 9. But he was not satisfied with 9 till the subtraction was completed.

The D Method in the Sixth Problem.

The process is division by a single number. There is no remainder. To secure 4 in the quotient the last 6 in the dividend must become a 16 by carrying one ten. Then 4 is tried in the divisor. The clue was

taken from the last figure in the dividend and the last figure in the quotient. The problem was solved backward.

The E Method in the Sixth Problem.

The subject saw that he must have a large remainder after the first division in order to have 9 as the second figure in the quotient. He first tried 3 for the divisor and 5 for the first figure in the dividend. This would not do. He then looked at the end and saw the divisor must be an even number or something that would divide a number ending in 6 evenly. He rejected 5 at once for the divisor. He then tried 4 in the divisor and 7 in the first place of the dividend. This verified.

The A Method in the Seventh Problem.

The subject saw that $4 + 4 = 8$. $12 - 8 = 4$. $5 + 7 + 1 = 13$. $13 - 13 = 0$. $3 + 2 + 1 = 6$. $15 - 6 = 9$.

The C Method in the Seventh Problem.

The subject saw at a glance that the missing figure in the first column must be 4. He said $4 + 4$ are 8 and $4 = 12$. Then said 7 and 5 and $1 = 13$. The missing figure in the second column is 0. Then added the last the same as the first.

In a general way the solutions are upon three levels.

1. *Direct substitution.* These subjects were so familiar with the different numerical combinations that the missing figure was brought to the front as soon as the data were apperceived. Some may wish to classify this as memory. But is it? In all probability this was the first time that these particular figures were ever given to the subject in exactly this relation. To the writer's mind it is the simplest or limiting case of reasoning. The series from it to the more complicated cases is an unbroken one, and the latter are, so far as I can discover, but compoundings of such simple associations. In this group come those solutions marked *C*.

2. *General Principle.* These subjects were not so facile with the mere numerical relations and were unable to reach the missing figures by direct association. They saw clearly enough the general principle involved but the supplying of the data had to take a slower course. The associative processes operated within limits imposed by the "general principle" apperceived. In this group come those marked *A* and *D*.

3. "*Trial and Error.*" The subjects using this method saw the relations less perfectly. They were not consciously guided by general principles but set about fulfilling the conditions empirically. The solution was often delayed and frequently the steps were repeated. In this group are found those solutions marked *B* and *E*.

It should not be concluded that the general reasoning powers of the subjects themselves are fully characterized by these tests. For these groups do not represent stages of develop-

ment The type selected for the solution of a problem was determined largely by the subject's familiarity with the conditions given. Perhaps all use the method of "trial and error" when a difficult problem is first attacked. DuBois-Reymond quotes Helmholtz who thus describes his mental processes in solving mathematico-physical problems:

"I must compare myself to a mountain climber, who, without knowing the way, mounts slowly and painfully. Often he must turn back for he can go no further. Sometimes through intuition, sometimes through accident he discovers a trace of a new way. This leads him forward again for a short distance and finally he reaches his goal. Then he discovers to his shame a royal way upon which he could have come, if he had only been clever enough to find the correct beginning."

General Conclusions.

1. The psychological process of reasoning as shown by these experiments does not follow the form of the syllogism, which is not even frequently employed to test the correctness of the conclusion. This is by no means to say that much, or even all, of the reasoning employed resists restatement in syllogistic form. The logical forms are like mathematical symbols in the range of their applicability and also in their abstract and unpictorial character. As well expect to find in 3.14159 a concrete picture of a circle and its diameter as to find in a syllogistic statement a reconstruction of the psychic processes that it symbolizes.

2. The processes are, so far as could be discovered, the familiar processes of association and apperception working under the special conditions of attention to the particular matter in hand.

3. Familiarity with the relations results in quicker solutions and in solutions that are more direct.

4. The established habits of procedure have an influence on the method of attack. This was so strongly marked in some cases as to cause a long use of the "trial and error" method when a general principle was plainly indicated by the data given. Dr. E. H. Lindley found a similar result in the case of children in his "Study of Puzzles."

5. The almost successful solution of a problem often produced mental "cramp." Because the solution was so nearly correct, the mind refused to try a new plan or to make the change of a single figure.

6. There is evidence for believing that reasoning is often an obscure insight or only a guess with an appeal for assistance to the method of "trial and error."

7. Some subjects stated that there was present a vague back-

ground which guided the associations. In some instances the general notion in the background was wrong, and this led to wrong procedure and to a long delay in the solution.

But what is the nature of this "background" or "mental set," and what influence has it on the reasoning process? Is the "mental set" anything more than a neural state brought into activity by seeing the problem? Perhaps we could say that there is a general arithmetical "principle" persisting in the "background" which determines the associations, but again, what is the nature of this general "principle?" Can it be anything more than a general habit of attention under certain circumstances?

The same problem may be put in this way. Reasoning may be defined as a series of successive limitations put on attention and association. But once more, what factors determine this process of limitation? We may say, in general, that it is determined by two things: By something *without*,—in this case the figures arranged in such a way as to form a problem. By something *within*,—the general knowledge of arithmetic and numerical relations and the momentary interest in the solution of the problem. These two influences acting jointly determine the "mental set," which in turn controls our attention and decides what course the associations shall take. But even this does not give us the final word regarding the nature of the "background" or "mental set." For the present this question must be left open.

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XX. On the Reading and Memorizing of Meaningless Syllables Presented at Irregular Time Intervals.

By MARGARET K. SMITH, Ph. D.

The natural tendency to read disconnected syllables in rhythmic groups and the comparative ease of memorizing rhythmic material are matters of common observation. In the laboratory studies made with meaningless syllables, it has been found practically impossible to avoid metrical groupings even when the syllables themselves are presented in strictly uniform series. A subjective tendency toward grouping forces upon them a metrical form which does not exist in their objective arrangement. During the writer's experiments upon Rhythm and Work[1] certain tests were made with the reading of meaningless syllables, in the course of which the question arose as to the extent to which objective inequalities may exist and a rhythmic grouping still be maintained, and, as a secondary question, what the rhythm secured under such difficulties signifies to the individual.

With a view to answering the above questions in connection with voice rhythm, at least, a series of experiments was made in the Psychological Laboratory at Clark University, Worcester, Mass., in the winter of 1900–1901, and though the experiments were unsuccessful as regards finding any order of syllables so irregular as to be wholly refractory to the rhythmic impulse of all the subjects, it seems worth while to give a brief account of them[2]

[1]Rhythmus und Arbeit: Wundt's *Philos. Studien*, Bd. XVI, 1900, 71-133.

[2]The work was under the general direction of Professor Sanford, to whom and to President Hall, the writer wishes to express her sincere thanks for many helpful suggestions, as well as for the many privileges of the laboratories, the library, etc.

I. Apparatus and Method.

The material consisted of meaningless syllables, while the procedure consisted in reading aloud these syllables as they appeared at irregular intervals on a horizontal rotating cylinder, similar to that of the Baltzar kymograph. The cylinder was 25 inches in circumference and 13 inches long, and was turned by an electric motor (acting through various retarding mechanisms) which caused it to rotate at the rate of one revolution in nine seconds. The syllables were constructed according to the general rules for the Ebbinghaus–Müller syllables[1] but as the peculiarities of English vowels and diphthongs do not admit of an arrangement identical with that of German syllables, the construction of the English syllables underwent some unimportant modifications. The chief aim was to secure syllables which were not suggestive one of the other, and which were as little as possible liable to suggest any associations whatever. These syllables were written in vertical columns (twelve in a column), on twelve strips of paper (four columns on a strip) which were fastened as required, on the cylinder above mentioned. A screen was placed in front of the rotating cylinder. The subject sat on a chair before it, and through an opening in the screen on a level with the eyes, he read each syllable as it moved past. Before beginning with the chief series, the syllables of which were written at unequal intervals, each subject read and learned four series of syllables written at equal intervals (1.75 inches). In reading these syllables the subject invariably fell into one of the four common verse rhythms. In all the other series, the syllables were arranged at uneqnal distances from one another. Though the intervals were not the same on any two papers, a description of one paper may give an idea of all.

First Paper.

Distance between the 1st and 2nd syllables, 2.625 inches.
Distance between the 2nd and 3rd syllables, 1.75 inches.
Distance between the 3rd and 4th syllables, 0.875 inches.

These distances, representing 3, 2 and 1 units respectively, were repeated until twelve syllables had been written in a column. Here of course we have not absolute irregularity, but rather a complex rhythm. On the second paper, the intervals were again in the ratio of 3, 2, 1, but were repeated more irregularly. On the third paper, the arrangement of intervals

[1]Ebbinghaus: Ueber das Gedächtnis, Leipzig, 1885.
Müller u. Schumann.
Müller u. Schumann: Experimentelle Beiträge zur Untersuchung des Gedächtnisses, Leipzig, 1893.

was again still more irregular, the distances varying from .625 of an inch to 5 inches. Care was always taken to keep such a distance between the syllables, that but one syllable could be seen at one time through the screen.

The experiments were made with the assistance of seven competent subjects, five men and two women including the writer. With one exception, these subjects were all unacquainted with the purpose of the experiment. Before the tests were finished, each had discovered that rhythm was involved in the reading, but no one had any idea that the aim of the investigation was to determine the extent to which irregularity among intervals might exist and rhythm still be maintained. The experiments lasted 25 days for each subject, and were conducted at the same hour every day.

The plan for daily work, after the preliminary days upon which series of syllables at regular intervals were read and learned, was as follows:

First Day—Dec. 5, 1900, 8.30 A. M. First paper.
Rotation of Cylinder, 9 seconds. Controlled immediately before and after every test.
Conductor, M. K. S. Subject, Mr. A.
1. Reading first Series (S_1)—20 Repetitions.
2. Reading second Series (S_2)—20 Repetitions.

Second Day—Dec. 6, . 8.30 A. M. First paper.
Rotation of Cylinder, 9 seconds.
1. (a) Reading of S_2 until learned. Repetitions necessary, 25.
   (b) Test. Reproduction S_2 (*Treffer*). Syllables reproduced, 4.
2. (a) Reading of S_1 until learned. Repetitions necessary, 20.
   (b) Test. Reproduction S_1 (oral reproduction of whole series). Syllables reproduced, 12.

Pause 2 minutes.

Second Paper.
3. Reading of S_3 —20 Repetitions.
4. Reading of S_4 —20 Repetitions.

The work for the remaining days was similar to that for the second day. With four subjects this plan was pursued without change. With the other three subjects, the only deviation was that each person was tested for a reproduction every day directly after the reading of each new series (20 Repetitions). The 20 repetitions were divided into two groups, with a pause of 30 seconds after the first ten. This procedure had nothing to do with rhythm, but was a means for resting the reader's eyes, and was a help in learning the syllables.

At the close of each experiment every day, the results were noted, including the introspections of the subject, as well as the observations of the conductor.

The memory test known as the "*Treffer*" was conducted as follows. Through an opening in the screen, a single syllable of the series which had been learned was presented. The sub-

ject was required to mention the syllable which came next in the series. Thus six syllables were presented, as a means to the reproduction of the other six syllables of the series. The order of presentation was systematically varied, so that the student never knew what part of the series would be presented.[1] The memory tests, though systematically carried out, had, of course, nothing to do with the rhythm, except that they gave greater purpose to the reading, and directed the reader's attention away from the rhythm.

The rhythm resulting from the reading was recorded as it was judged by the conductor. A certain control of this judgment was attempted by means of separate kymograph records of the reading of each subject, but the main reliance is placed upon the subjective judgment of the conductor of the experiment. In a strict sense, therefore, the results might be supposed to be influenced by the rhythmic tendencies of both the subject and the experimenter, but the kymograms give sufficient ground for thinking that the conductor's judgments were in the main correct.[2]

The following table, covering the tests of a few days with a single subject, will give some idea of the observations made and the results with reference to rhythm.

With one exception, to be mentioned later, the experiment for which a part of the record is given below, was the least satisfactory, in regard to rhythm, of any that were made. Reading from the rotating cylinder was hard for Mr. K. The motion confused his vision, while the pronunciation of meaningless syllables was very difficult. At almost every test, the effort involved was so great as to be disagreeable. Notwithstanding these difficulties, a constant effort to make unequal intervals equal was to be observed. After some facility had been attained, rhythm always appeared. With the perception of rhythm came pleasant feeling, and a sensation of relief. The learning of the four series on one paper required for Mr. K. from 30 to

[1] Müller u. Schumann: Beiträge zur Untersuchung des Gedächtnisses, Leipzig, 1893.

[2] These kymograms were secured in the following way: After reading one of the series, another paper with the same spacings, but containing other syllables, was put on the brass cylinder which rotated as usual. After some repetitions for practice, the subject read the syllables into a small funnel connected by rubber tubing with a tambour. The vibrations of the elastic membrane of the tambour were conveyed to a pen which inscribed the movements on a paper on a second kymograph cylinder. The resulting kymograms showed the reader's groupings of the syllables. In every case, the kymogram showed a rhythmic grouping which upon the whole agreed with the impression received by the conductor at the regular reading. Owing to a difficulty in finding suitable explosive consonants for the beginning and end of the syllables that were read into the funnel, the kymograms were not always easy to decipher in detail, which probably accounts for some at least of such differences as appeared between the conductor's record and those of the kymograph.

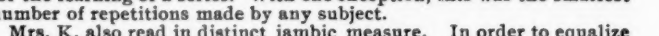
Subject, Mr. K. *Rhythm Results.*

Date.	Days.	Paper.	Series.	Repetition preparation.	Repetition for reproduction.	Rhythm.	Remarks.
Dec. 13.	1	1	S1	20		⏑–|⏑–|⏑–|⏑–|⏑–|⏑–|	
			S2	20		⏑–|⏑–|⏑–|⏑–|⏑–|⏑–|	
Dec. 14.	2	1	S2		45		Rhythm perceptible, but so irregular that it could not be indicated.
			S1		25		
			S3	20			Same true of new Series 3 and 4.
		1	S4	20			
Dec. 17.	3	1	S4		25	⏑–|⏑–|⏑–|⏑–|⏑–1|⏑–|	Iambic measure clear.
			S3		25	⏒⏑|⏒⏑|⏒⏑|⏒⏑|⏒⏑|⏒⏑|	Trochaic. Subject tried to group in 3s and 4s, failed.
			S2	20			Grouped in 3s without special accent.
		2	S1	20			Grouped in 4s. Rhythm not to be indicated.
Dec. 18.	4	2	S1		30	––|⏑–|–|⏑–|–|––|––|	
			S2		30	––|⏑–|–|⏑–|–|––|––|	
			S3	20			Irregular. Rhythm not to be indicated.
		2	S4	20			Irregular. Rhythm not to be indicated.
Dec. 19.	5	2	S4		10	––|⏑–|–|⏑–|–|⏑–|––|	Rhythm irregular but with a tendency to Iambics.
			S3		20	––|⏑–|–|⏑–|–|⏑–|––|	
			S1	20		––|⏑⏑–|––|⏑–|⏑–|–|	A strong effort to secure regularity, giving a certain rhythm.
		3	S2	20		––|⏑⏑–|––|⏑–|⏑–|–|	
Dec. 21	6	3	S2		16	––|⏑⏑–|––|⏑–|⏑–|–|	Iambic and anapaest clear.
			S1		15	––|⏑⏑–|––|⏑–|⏑–|–|	
			S4	20		––|⏑⏑–|––|⏑–|⏑–|–|	Though this is the measure, the Rhythm was hardly perceptible.
		3	S3	20		––|⏑⏑–|––|⏑–|⏑–|–|	
Dec. 22.	7	3	S3		12	––|⏑⏑–|–––|⏑–|⏑–|–|	Somewhat iambic, but very irregular.
			S4		15	––|⏑⏑–|–|–|⏑–|⏑–|–|	
			S1	20		––|⏑–|–|–⏑|–|–⏑|––|	Trochaics somewhat marked.
		4	S2	20		––|⏑–|–|–⏑|–|–⏑|––|	
Dec. 24.	8	4	S2		10	––|–⏑|–|–⏑|–|–⏑|––|	About the same as above. Trochaics marked.
			S1		10	––|–⏑|–|–⏑|–|–⏑|––|	
			S4	20		––|–⏑|–|–⏑|–|⏑–|––|	Much as before.
		4	S3	20		––|–⏑|–|–⏑|–|⏑–|––|	
Jan. 3	9	4	S3		15	––|⏑–|–|⏑–|–|⏑–|––|	Iambics somewhat marked.
			S4		15	––|⏑–|–|⏑–|–|⏑–|––|	
			S1	20		⏑–|–⏑|⏑⏑–|⏑–|––|	Indefinite, but Rhythm perceptible.
		5	S2	20		⏑–|–⏑|–⏑⏑|⏑–|–––|	

60 repetitions of each series. The subject preferred to group the syllables in threes, but was seldom able to do so. Upon the whole the trochaic grouping predominated. With other subjects the same tests gave different results.

From the beginning Mr. M. secured a distinct iambic measure. To do this he was obliged to make many modifications, so that the effect was markedly different from the ordinary verse measure. Where the similarity to verse rhythm was lost, a resemblance to a dancing movement was to be observed. From 23 to 35 repetitions were necessary for the learning of a series. With one exception, this was the smallest number of repetitions made by any subject.

Mrs. K. also read in distinct iambic measure. In order to equalize the intervals, she memorized certain syllables at the first or second reading, and then brought them in as she needed them to make the measure. The resulting iambic measure was as follows:



This test indicated that the intervals between the members of a group and the intervals between the groups themselves are very different matters. If either set of intervals be equalized, the rhythm is marked. If both sets be equalized the rhythm is smoother, but not necessarily more musical. From the inequalities of the time intervals Mrs. K. inferred the inequalities of the space intervals. By reason of the constant rhythm maintained, Mrs. K. learned each series more quickly than any of the other subjects.

Another subject, Mr. T., found the reading of the same syllables very difficult. He reported a "feeling of strain" in trying to catch the passing syllables. The unequal intervals were the source of some unpleasant feeling which the subject did not trace to the right source. He thought that the number of syllables was not the same in all the series. Although he read throughout in trochaic measure, his manner of reading varied greatly. His measures were characterized by pauses and shades of accent that come under no known rules of rhythm. To him, learning the syllables was very difficult, and very unpleasant. He resented the demand on his attention.

Mr. L. found the same syllables easy. He read constantly in iambic measure. He knew nothing of the purpose of the experiments, yet he constantly talked of rhythm. He found the irregularities very amusing. The rate of rotation (9 seconds) was too slow for him, so that he made many fantastic associations.

Another subject, Mr. A., secured a distinct rhythm by a procedure different from that of any other person. He grouped in twos and threes, often securing the accent by substituting time for stress. He was always successful in securing an adaptation of sound and time to the space intervals of the series. To him, the difficulties arising from unequal intervals were entirely subjective. He believed that he voluntarily created the effects. The measure secured was agreeable, and amusing, and aided in very accurate memory work. The subject said, "The rhythm is divided into twelve unequal parts, and the task is to make those parts equal. Yet it is a time and not a space equality. A new arrangement causes a feeling of uncertainty, a slight annoyance at not being able to run at once into an old, or indeed into any rhythm. This somewhat unpleasant feeling is tempered by a curiosity as to what can be done with the rhythm. When one cannot read the new series as the last was read, uncertainty and annoyance follow. After some effort, the rhythm settles itself. Satisfaction arises and things become easy." In reading the tenth paper, the first eight repetitions gave no satisfactory rhythm. Finally, something like the following was secured | — | — | ⏑ ⏑ — | — | — | — ⏑ ⏑ | ⏑ — |.

This is not a verse rhythm of course. The subject reported: "The long intervals between the first two syllables broke up my previous method of grouping. The long intervals determined one kind of foot, the short ones quite another kind. The difficulty of bringing the syllables to a satisfactory stop at the end was a source of discomfort. It was like a strain of music entirely unphrased, no cadence anywhere." The grouping varied from single syllables to anapaests, and dactyls. In the latter, time instead of stress gave the effect of accent. The single syllables were read, each in the time of the group of three. The iambic foot at the end was made merely to satisfy the ear of the subject. In the eleventh paper, the following rhythm was secured. | — ⏑ | — ⏑ | — ⏑ | — | — ⏑ | — ⏑ | — |. The objective spacings were very unequal. The whole effect of regularity and equality was secured by the voice. In the twelfth paper, the intervals varied from three-fourths of an inch to five inches, yet every series was read in trochaics. The longest intervals being at the end of the paper, the last syllables were learned by heart, and brought in at the right time. The learning of a series required from 25 to 55 repetitions.

The last set of tests in this part of the experiment was conducted by Dr. Sanford, the conductor of the former tests being now subject. On the first paper, the intervals were equal, yet, until the seventh reading, no settled rhythm appeared. Then there seemed to be a rising and falling accent upon the first and second syllables of each pair, thus, | ∠ ⏑ | ∠ ⏑ | ∠ ⏑ | ∠ ⏑ | ∠ ⏑ | ∠ ⏑ |. In the second paper, the measure seemed to be iambic. The syllables of the third paper seemed to fall into triple time, thus, | ∠ ∠ ⏑ | ∠ ∠ ⏑ | ∠ ∠ ⏑ | ⁄ ∠ ⏑ |. Later, the reading seemed to approximate anapaests, or iambics. The subject reported: "The spaces between the syllables appeared to be equal, but some syllables appeared to be unduly hastened, while others were delayed. Was disturbed by the fear that I should not finish the series in time. In certain relations, some syllables are difficult to pronounce. The syllable 'war' following a difficult syllable was almost unpronounceable."

These tests constituted the main part of the investigation, and as concerns the question of a limit of inequality and irregularity of intervals in connection with voice rhythm, led to wholly negative results. *Every subject tried of his own accord to make unequal intervals equal, or at least to reduce them to some rhythmical grouping, and each succeeded. Each one strove to secure a rhythm agreeable to the ear, and, before any learning could be done, this had to be secured.*

II.

Because of the failure to obtain a definite answer to the question, Dr. Sanford proposed a series of tests in which the syllables should be presented still more "antirrhythmically," *i. e.*, the inequalities of the intervals should be greatly increased and should not recur even in the twenty repetitions of the series.

Six series of meaningless syllables (twelve syllables in a series) were arranged on a paper thirteen inches in width and forty-two feet in length. This length allowed the repetition of each series twenty times, at distances between the syllables that were never twice the same, and varied from three-fourths

of an inch to ten inches. This variation extended to the different series, no two of which were arranged in the same way. The syllables, similar in construction to those used in the previous tests, were printed instead of written. Blank paper four feet in length was attached to each end of the long paper. This strip, now fifty feet long, was rolled tightly on the cylinder. The latter being set in motion, four feet of blank paper first rolled off; then the reading of separated syllables through an opening in the screen began and continued until the whole fifty feet had been run off. By the time the whole strip had been run off, one series had been read twenty times. The paper being readjusted, the next series was read in the same manner as the preceding one. Two new series were read each day, and the learning was tested as before.

The point was to find whether, with the increased and unrepeated inequalities, the subject would still read rhythmically. Of the set of subjects who served in the earlier tests, six were also employed for the new ones. In addition four new subjects were selected, who had had no experience in work of this kind.

The results will be sufficiently clear from the individual reports:

Mr. K., who had found the previous work sufficiently trying, found this confusing, annoying, and very difficult. Towards the close, some signs of rhythm were perceived. The learning was very imperfect.

As in the previous tests, Mr. M. read in distinct iambics, and learned easily.

Mrs. K., as before, read in strong iambics, and learned quickly.

Mr. S. found more difficulties than before, and could not learn until something like trochaics was secured.

Mr. A. found more difficulty than in the previous work, but after securing an anapaest movement, he learned readily.

On the first day, Miss S. had a distinct sensation of rhythm. Later she seemed to read in iambic, anapaest, or dactyllic movements.

Mr. H. (one of the new subjects) had very little sensation of rhythm, though he finally grouped in twos. He could not learn the syllables, but thought that he could have done so by singing them.

In reading the same series, Mr. H.'s son, a boy of thirteen, read in iambics at once. This subject knew nothing about the unequal intervals, but was annoyed by "something that broke the beat," so that he could "hardly get the syllables back into order." He said "it was like men stepping. The band played, and something came and broke the march. Several men kept time. They broke step suddenly." Toward the close of the tests, this boy sang the syllables in dactyls

and kept time very well. The singing was quite spontaneous. This lad played his way through the tests, and enjoyed the reading greatly.

Another of the new subjects grouped the syllables in threes by beating with her finger. Her perception of rhythm was very slight.

The last of these subjects, Mr. S., swayed his shoulders to some rhythmic movement which he located in the screen. Otherwise he had a very slight perception of rhythm.

III.

In summing up the results of this investigation into the limits of the inequality and irregularity of intervals in connection with the rhythms of speech, it may be stated that each subject tried to equalize unequal intervals. Of eleven subjects, nine had a distinct impression of rhythm resulting from a greater or less equalizing of the intervals. The other two subjects had but vague impressions of rhythm.

Some of the devices for securing equality were as follows:

1. Certain syllables were memorized at the first reading. Later, these syllables were spoken before they appeared at the opening in the screen, or they were held back and spoken after they had passed. This hastening or delaying of the syllable was according to the need of the individual.

2. Manner of articulating became a factor in equalizing intervals. Quick, distinct utterance of a vowel lengthened the interval, while holding it with a glide shortened the interval.

5. Sometimes the suspension of the rhythm had the effect of equalizing the intervals. This differed distinctly from a pause between feet.

6. Beating time with hand or foot while reading was an important factor in securing and maintaining equal intervals.

7. Repetition of the series was a great aid in securing regularity and equality among intervals. It was also a means of developing an apprehension of rhythm. The equality was not determined by the shortest interval, but by some one interval to which the others could be the most easily adapted.

General Observations.

Excepting Mr. H., who had no theories regarding rhythm, the subjects all believed that without orderly speech movements, and approximately equal intervals, regularly succeeding one another, the learning of a series of syllables was impossible. When the apprehension of rhythm accompanied such movements, the best condition for learning existed.

Some of the subjects appreciated the importance of keeping one rhythm. Mr. M. and Mrs. K. established an iambic rhythm, and maintained it throughout their work. These two learned with much greater ease than those who showed greater variations in rhythm.

After the pleasant feeling resulting from rhythm had been once experienced, it came to be regarded as very important in learning, while the unpleasant feeling resulting from irregularity and confusion was an absolute hindrance to the same work.

Although the learning of the syllables was the chief aim of all but one of the subjects, the conscious effort was directed mainly to the equalization of the intervals. After a rhythm was established, its tendency to persist and to dominate the mental state was marked. So long as a rhythm remained unchanged, the substitution of one letter for another, at the beginning of a syllable, was almost impossible. A syllable mispronounced at the beginning of the work must remain so throughout the test. Also the rhythm of one series had a tendency to dominate the next series. A total change of intervals did not always insure a change of rhythm. This was especially shown in the work of Mr. M. and Mrs. K.

In these tests, both primitive (single) and complex rhythms were developed. As a rule the primitive rhythm when developed ran through the whole series, but sometimes, owing to the inequalities of the intervals, in the same series, a curious mingling of simple and complex rhythms might occur.

In reading with primitive rhythm, no stress is placed on the syllables. The rhythmic expression is secured by the management of the intervals between the syllables. The subject realized the monotony of this reading, and as soon as facility was secured, made an effort to avoid it. The first reaction against "level" reading was shown in a tendency to accent every syllable, a procedure only less tedious than the one it supplanted. Just here arose the necessity for grouping. The limitations of respiration made it impossible to accent more than three syllables with one breath. A strong accent on each member of a group involved still more frequent inhalations of breath. The untrained subject was obliged to take a breath at the end of every two or three syllables. These peculiarities of breathing are shown clearly on the kymograms.

The next step from a simple towards a more complex rhythm consisted in grouping, and placing an equally strong accent on each member of the group. After some repetitions, the subjects (except Mr. H.) all showed a tendency to accent some one member of a group, especially, so that the effect of verse rhythm was secured. Of seven subjects who served for the regular experiments, four grouped mostly in iambics, and three mostly in trochaics. In the extra tests, only the youngest of the new subjects read in iambic measure. Among the subjects for the regular tests, two read exclusively in iambics, and one nearly always in trochaics. The other subjects read more or less in dactyls or anapaests, though they seemed to prefer iambics or trochaics.

The exigencies of the irregular arrangement often made necessary a grouping that, though rhythmic, belonged to no one of the four-verse rhythms. At times three of the four typical measures were combined, while at other times, the reading involved one or two of the regular measures, together with groups of evenly accented syllables, and even with isolated members strongly accented. Often, while the conventional group was preserved, the rhythmic effect was dominated by the single syllables. In three cases, the rhythm was like that of a dancing movement.

The musical effect of the anapaestic and dactyllic measures was greater than that of the iambics, and trochaics. With the three-part measures, the learning of the series was no more difficult than with the two part measures, but with the former the reproduction of syllables—after an interval—was much less certain than with the latter.

SPINOZA AND MODERN PSYCHOLOGY.

By Amy E. Tanner.

Spinoza's proof *de more geometrico* and his great labors to reduce all the statements of his ethics to this form, have oftentimes blinded the student to the true modernity of his ideas. To find peering out from his stilted phraseology and labored demonstration a theory of the origin and development of the mind that is essentially modern and that forecasts much of modern method, is an interesting experience, especially when we realize that this was probably the theory which he employed unconsciously in everyday life.

With Spinoza's general theory every one is familiar. There is but one substance, God, which manifests itself under the two attributes of thought and extension. These two attributes run parallel to each other in all their modes, and hold no causal relationship to each other except as they are each referred to God.

Here at the very beginning we see an interesting obscurity in Spinoza's thought. He says distinctly that mind and extension are not different substances but the same seen under a different attribute. Is it not then quite as unsuitable to speak of a parallelism between them as of a causal relation? Ought we not rather to say that when God reveals himself as thought then this extension appears? But leaving this aside, if he admits that there is but one substance, how can he deny a causal relationship between all forms of this substance?

Taking the theory more in detail and rearranging the order in which Spinoza gives his proofs in order to show the parallelism between him and modern theory, we get the following.

In Part 3, Props. 6, 7 and 9, Spinoza states that everything endeavors to persist in its own being, and that this endeavor is its actual essence. When referred to the mind solely, the endeavor is called will; when to the mind and body in conjunction, appetite, and when the mind is conscious of its endeavor, the consciousness is desire. What would Spinoza call the endeavor when referred solely to the body?

The similarity of this to our modern idea, is very striking. We tend more and more to look upon our mind as it functions to-day as the residuum of countless efforts at self-preservation. One theory that is very commonly accepted states explicitly

that mind arose in the effort of the body to preserve itself, and that when no further effort is necessary, mind retires. This again makes striving the essential feature of the mind, the matrix, so to speak, out of which are differentiated later thought and feeling.

This also is Spinoza's idea, for he goes on to say (Part 3, Props. 11 and 12) that since the essence of the mind is will or the attempt at self-preservation, we shall have pleasure in the passage to a greater perfection and pain in the passage to a lesser one, and we shall endeavor to conceive only the first. The modern pleasure-pain theory, while it realizes more fully than Spinoza could the difficulties in the way of accepting this idea unreservedly, still has no better general theory. It too, says that on the whole pleasure is the sign of well-being and pain of harmfulness to the body.

These general assumptions that Spinoza makes with regard to persistence and to pleasure and pain, make his theory essentially an evolutionary one, in spite of his efforts to make it mathematical. And yet this very endeavor to employ mathematical demonstration is one proof of his modern spirit. If, instead of geometry, he could have used such forms as now are employed both in our physical and psychological laboratories, he would have had the exactness for which he so longed without at the same time petrifying his theory. But he was too early in time for those forms of mathematics.

When we take up more in detail Spinoza's theory of knowledge, we see even more clearly both his closeness to the modern spirit and his separateness from it. He does not argue as to the origin of knowledge. He assumes it in Part 2, Axiom 3, where he says: "Modes of thinking, such as love, desire or any other of the passions, do not take place unless there be in the individual an idea of the thing loved, desired, etc.," and in Prop. 13, he says and demonstrates that "The object of the idea constituting the human mind is the body, in other words, a certain mode of extension which actually exists, and nothing else," and in Prop. 11, "The first element which constitutes the actual being of the human mind is the idea of some particular thing actually existing."

That is, the world of extension is the object without which the mind would have no ideas, that is, actually no existence. Surely this comes very close to being a sensationalistic theory of knowledge, in spite of a formal assertion which he makes later on. For all practical purposes it is both sensationalistic and causal, as one can reason from mental to bodily effects and from bodily to mental with complete accuracy. What he really is saying is that without some material with which to work the mind could have no existence, and this material must

be the other attribute of God, the one substance. If God stands ready to display a certain mode of extension every time that there is a certain mode of thought, it surely is not far from being a practical cause and effect relation between the two, though it does seem rather hard on God to make him into a go-between.

Since the object of the human consciousness is only the body, then the mind (Part 2. Props. 14 *et seq.*) will perceive things in proportion as the body is capable of receiving impressions; the ideas that we have bear a direct relation to the number and delicacy of the sense-organs and to our general bodily structure. What we consider our knowledge of external nature is in reality far more a knowledge of our own bodies. To take a modern instance, if we say a book is heavy we mean that our muscles react in a certain way for which our mind has a certain name. Another person may say that the same book is light. The quality of the object is really due to the condition of our sense-organ.

This is the beginning of Berkeley's idealism, one would say, as well as of much of our modern educational and ethical theory, which sets about giving sane ideas of the world by developing a healthy body. If the content of the mind consists solely of its consciousness of bodily changes, then surely nothing is more important to mental balance than bodily health. I do not know that Spinoza elaborated this idea in any of his writings, but his life exemplified his belief in it.

Along with this goes naturally a theory of illusions and of association of ideas (Props. 17 and 18). If we have any idea of an external object, we shall consider it as actually existent, unless we can disprove its existence by means of the other senses. Memory and imagination are explained as due to the permanent changes made in the soft parts of the body by external bodies striking upon the bodily fluids, which in turn strike on these soft parts and alter them. Then if, at another time, without an external body striking the fluids, the fluids strike the soft parts, the idea of the external body will be aroused. In the same manner, if two ideas have been aroused at once, the later arousal of either tends to call up the other. If Spinoza had known a little more about the nervous system he would have written James's chapter on Association of Ideas some two hundred and fifty years ago.

In Prop. 23 we find a valuable suggestion as to psychological method. The mind cannot know itself except in so far as it perceives the ideas of the modifications of the body; that is, to know ourselves we must study perceptions and sensations primarily, not theorize abstractly on the nature of the mind. We must observe the effects of outside stimuli and trace the

connections between external objects and conscious manifestations. We can imagine that Spinoza would heartily adopt experimental psychology, especially as it would afford some of the mathematical demonstration which he loved so well.

In Props. 38 and 39 of Part 2, he also hints at the reason why man is social. Some ideas are common to all men because their bodies agree in certain respects. Then the more that a man's body has in common with other bodies, whether human, animal or inanimate, the more will he have in common with them and the more adequate will the ideas be. That is, to use modern language, our brotherhood with man is due to an actual physical likeness. Or, in Spinozistic speech, each of us is but a mode of the one substance, and the more that mode has in common with other modes whether of thought or extension, the more will we know them. Sympathy rests upon a basis of like feeling, and like feeling is impossible unless the one body is like the other body.

These adequate ideas must not be considered as concepts, or what Spinoza calls general ideas. The latter arise from the fact that our imagination is unable to picture distinctly all the individuals of a class, becomes confused, and loses sight of the minor differences, thus confounding the individuals and keeping clearly in mind only the points in which they all agree. This sort of knowledge can not be depended on, while adequate ideas and intuition can be.

But when we ask how we can know a true idea, we come to what is probably the fundamental difference between Spinoza and modern thought. In Part 2, Prop. 43, he says, "He who has a true idea simultaneously knows that he has a true idea and cannot doubt of the truth of the thing perceived." Again and again he asserts this and he refuses to discuss the question of whether the idea truly represents the object, saying, "As to how a man can be sure that he has ideas that agree with their objects, I have just pointed out with abundant clearness that his knowledge arises from the simple fact that he has an idea which corresponds with its object, in other words, that truth is its own standard."

The centre of his proof seems to be his assumption that we are necessarily conscious of any idea that we have, that is, that consciousness and self-consciousnees are really the same, or that if we have an idea we must know that we have it, and not only that, but must know all its characteristics. Then we ought to know not only true ideas at sight, but false ones, and never ought to be deceived. Spinoza is not at all satisfactory here. He says that a false idea is due to confused, fragmentary or inadequate ideas, but still does not explain why we do not

perceive this confusion, etc., if the idea carries its own sign with it.

In his theory of the will he is once more very modern. It is not in the nature of reason to regard things as contingent, but as necessary. The mind is always determined by a cause, which is determined by another cause, and so on *ad infinitum*. There is no freedom of the will.

Still more, both will and understanding are only abstract terms for a sum of particulars. There is no will in the abstract apart from particular volitions, and there is no particular volition apart from ideas. Will and understanding are one and the same thing. There can be no volition or negation save that which the idea, by the very fact of its being an idea, involves (Part 2, Props. 48 and 49). An idea is not like an inanimate picture on a panel he says in various places. It is a living, growing thing, which by its very nature involves a judgment, an affirmation, that is, a volition.

We could hardly have James's theory that all consciousness is motor, stated more explicitly in the absence of modern proofs of it. The denial that mind and volition have an abstract existence, an existence apart from thinking and willing, and the assertion that the essence of the mind is will and that understanding and will are identical;—these assertions take Spinoza over into the most modern of modern thought. The inner need for exact proof must indeed have been compelling in order to force such ideas into the strait-jacket of geometrical demonstration.

ON THE NAMING OF COLORS.

By H. E. Houston and W. W. Washburn.

The ancients, as is well known, had comparatively few color names and used these loosely. This deficiency does not necessarily mean an inability to discriminate colors, nor does an increase in color vocabulary mean an increase in the nicety of discrimination. The completeness of the color vocabulary depends rather on the extent of the social needs of designation. The color names of savage and semi-civilized peoples of the present day have been found to be quite defective, though their powers of discrimination are exceedingly fine.

Our own system of color names and their application leave yet a good deal to be desired. Efforts have been made at various times to introduce arbitrary standards, but none has been widely accepted, except the designation of the standard hues by the corresponding wave-lengths in the spectrum or by reference to the Fraunhofer lines. For the purples, grays, and the multitude of tints and shades this, of course, makes no provision.

On the other side of the question—the precision with which color names are now actually applied—a few observations have been made and at least one experimental study has been carried out.

Prof. H. K. Wolfe[1] made an investigation of the color vocabulary of school children. The children were asked to name colors which were shown to them. The colors used were oil pigments applied by means of a brush to cardboard, previously treated with a coating of glue. Comparison was made on the basis of age and not of class standing. The answers of those deficient in color vision were classified by themselves. The results were then tabulated, giving the correct answers in 1,000. Males and females were classified separately. Colors are named in an entirely different order from that given by Preyer. Tables are given showing the rate and time of improvement, also sex differences. Many colors are absurdly named, and the conclusion is that the color instruction has been very defective.

Our own experiments were in general method akin to those

[1] H. K. Wolfe: Studies from the University of Nebraska, 1890.

of Wolfe, but carried out upon subjects of a greater range in age. The colors selected for these sets of tests were the twenty-four spectrum colors of the Prang Educational Company. The purpose of the experiments was to see how the colors would be named by school children and college students if left to themselves and not aided by any artificial system. The colors were cut in squares twenty centimeters on the side with a border of black of two centimeters in width. These colors were held up before the various classes in a good light, direct sunlight being avoided. The pupils observed the colors and wrote their answers independently on paper. In the lower primary grades where the children were unable to write they were questioned independently, out of the hearing of the other pupils. In other respects the tests were exactly the same as in the other grades. The colors were purposely arranged in the order of every sixth, *i. e.*, if we represent the colors of the Prang system by the numerals 1, 2, 3, . . . 24, the order in which the colors were presented would be 1, 7, 13, 19; 2, 8, 14, 20, etc., . . . 24. The colors were each exhibited for about one second. A considerable number of names were given, including the names given to various colored fabrics, the colors of flowers, of plants and of concrete objects, such as brick-red, etc., but all of these together form a very small percentage of the whole number of answers. It was, therefore, thought best to classify these under the headings of red, yellow, orange, green, blue, and purple.

The first of the following tables gives the measurements of the Prang colors in terms of the five color standards used in the Physical Laboratory at Columbia University. Thus 90° of the first red of the Prang series plus 10% of white matches 57% of the Columbia red, plus 6.7% of the Columbia blue, plus 36.3% of black.

The later tables give the percentages of answers for each of the colors for the kindergarten pupils and for the whole number of subjects tested.[1] The accompanying curves give the latter results in graphic form, the ordinates denoting the percentage of answers for each Prang color and the abscissæ denoting the position of the same color in the spectral color system. This position was determined by estimating the distance between the successive steps in the following way:—A large circle was drawn on which were placed the twenty-four colors in their regular order, from 1 to 24. Then the distances were altered until they seemed to represent the proper differences in color sensation. The estimates were made by seven subjects and the abscissæ used are the averages of the seven estimates.

[1] The percentages for the kindergarten year only are here given separately as there are no striking differences among the other years.

Measurements of Prang Colors. Columbia Standards.

Prang Colors.	*R.*	*O.*	*Y.*	*Y.*	*B.*	*BK.*	*W.*
90 R 10 W	57.0	.....	.....	.....	6.7	36.3	.....
96 R R O 4 W	100.0	.....	.....	.....	.....	.....	.....
98 R O 2 W	86.4	13.6	.....	.....	.....	.....	.....
100 O R O	50.0	50.0	.....	.....	.....	.....	.....
100 O	.....	71.8	8.4	.....	.....	14.4	5.4
100 O Y O	.....	61.7	26.3	.....	.....	6.7	5.3
100 Y O	.....	40.5	42.5	.....	.....	10.2	6.8
100 Y Y O	.....	18.7	77.3	.....	.....	.....	4.0
94 Y + 6 BK	.....	.....	81.2	18.8	.....	.....	.....
84 Y Y G + 16 BK	.....	.....	47.0	53.0	.....	.....	.....
98 Y G + 2 W	.....	.....	28.3	71.5	.....	0.2	.....
100 G Y G	.....	.....	11.6	56.6	.....	31.8	.....
100 Y	(R .644)		2.1	39.9	.....	58.0	.....
100 G B Y	(O .614)		.....	27.7	−9.6	62.7	.....
100 B G	(Y .585)		.....	29.4	28.2	42.4	.....
100 B B G	(G .518)		.....	23.6	67.2	8.8	0.4
62 B + 38 BK	(V .452)		.....	−4.8	88.1	.....	7.1
100 B B V	.....	.....	.....	2.4	92.7	2.9	2.0
100 B V	1.9	.....	.....	.....	56.6	41.5	.....
100 V B V	4.3	.....	.....	.....	45.2	50.5	.....
100 V	7.1	.....	.....	.....	38.6	54.3	.....
99 V R V	12.0	.....	.....	.....	14.1	73.9	.....
96 R V + 4 W	19.8	.....	.....	.....	8.8	71.4	.....
90 R R V + 10 W	38.7	.....	.....	.....	4.7	56.6	.....

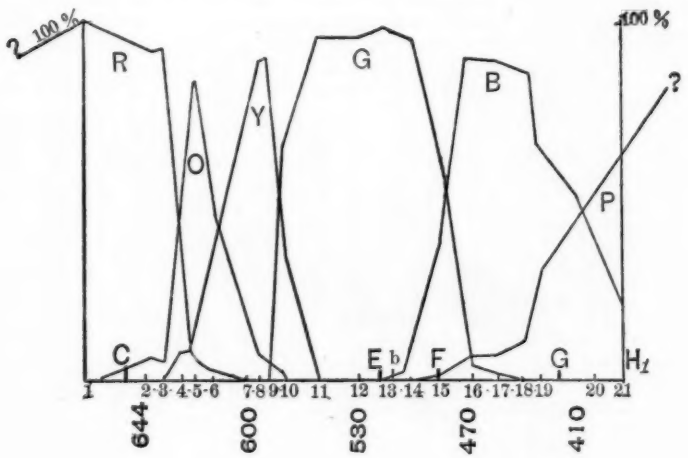
No. of Experiments, 48–53. Kindergarten Pupils. Av. Age 5.

No.	Name.	Red.	Orange.	Yellow.	Green.	Blue.	Purple.
1.	R	100					
2.	RRO	97.8	2.2				
3.	RO	95.7	4.3				
4.	ORO	37.0	48.2	12.8			
5.	O	14.0	50.0	36.0			
6.	OYO	5.0	57.4	37.6			
7.	YO	3.0	31.0	66.0			
8.	YYO		12.0	88.0			
9.	Y		11.0	84.0	5.0		
10.	YYG			40.5	51.0	8.5	
11.	YG			5.5	96.0	8.5	
12.	GYG			3.3	89.2	7.5	
13.	G			3.3	84.9	11.8	
14.	GBG		*Miscellaneous.*		88.0	12.0	
15.	BG				67.2	32.8	
16.	BBG		5.5		11.0	83.5	
17.	B		6.0		3.5	90.5	
18.	BBY		6.5		1.5	90.5	1.5
19.	BY					94.0	6.0
20.	YBY					70.5	29.5
21.	Y	8.0				54.0	38.0
22.	YRY	21.6				31.8	40.3
23.	RY	74.4				12.8	12.8
24.	RRY	87.2					12.8

Averages of all Experiments.

No. of experiments, 1,573. Ages, 5 to 24 years.

No.	Name.	Red.	Orange.	Yellow.	Green.	Blue.	Purple.
1.	R	97.1	0.9				
2.	RRO	93.9	6.1				
3.	RO	96.8	3.2				
4.	ORO	19.2	80.8				
5.	O	4.4	95.6				
6.	OYO	0.8	41.1	58.1			
7.	YO		25.2	74.8			
8.	YYO		8.3	91.8			
9.	Y		1.9	98.1			
10.	YYG			23.6	76.4		
11.	YG			3.8	96.2		
12.	GYG			2.9	97.1		
13.	G				99.8	0.2	
14.	GBG		*Miscellaneous.*		97.2	2.8	
15.	BG				58.1	41.9	
16.	BBG		0.4		2.4	97.2	
17.	B		0.5			93.0	6.5
18.	BBV		0.6			84.2	15.2
19.	BV					69.2	30.8
20.	VBV					66.1	
21.	V	5.3				31.7	63.0
22.	VRV	29.4					70.6
23.	RV	92.6					7.4
24.	RRV	98.1					1.9



As points of special interest in the curves may be noticed the somewhat broad range of colors that were almost always denominated "red," "green" or "blue." For "orange" and "yellow" the total range is perhaps nearly as great, but the high frequency of usage is confined within extremely narrow limits. Another item is the sharpness of the demarkation in the usage of "green" on the side toward red as compared with its wide range on the side toward blue, corresponding to the common uncertainty of "telling green from blue." In a somewhat similar fashion "blue" and "purple" overlap. It is also interesting to notice that the pair "blue" and "yellow" do not overlap at all, though they might perhaps be expected to do so, if it were actually possible to see in green a mixture of yellow and blue as some have thought could be done. A similar, though smaller, gap separates the usage of the names "red" and "green." "Green" and "purple" (here equivalent to violet probably) were, however, applied to identical colors by different individuals.

PSYCHOLOGICAL LITERATURE.

The Nature of Truth; an Essay, by H. H. JOACHIM. Oxford, Clarendon Press, 1906. pp. 182.

Pragmatism, a New Name for Some Old Ways of Thinking; popular lectures on philosophy, by W. JAMES. New York, Longmans, Green & Co., 1907. pp. xiii, 309.

These two works lie too far beyond the confines of psychology to receive detailed treatment in a psychological journal. They offer, however, an excellent illustration of that fundamental difference of temperament which Professor James lays at the basis of all philosophical differences; and they remind us that the psychology of temperament is so far in its earliest infancy.

Mr. Joachim dismisses pragmatism, in his preface, as unworthy of serious consideration. "In substance the doctrine remains what Plato proved it to be: not a new theory of truth, but a denial of truth altogether." His own object is to "examine certain typical notions of truth, one or other of which . . . has hitherto served as the basis of philosophical speculation." The first of these regards truth as correspondence; the second, as a quality of entities entirely independent of mind; and the third as coherence. These are discussed in as many consecutive chapters, and the essay concludes with a fourth chapter on the negative element and error. The upshot is that "the coherence notion fails of complete success; but it has carried us further into the heart of the problem than either of the other two notions, and it has maintained itself against difficultles to which they succumbed."

Professor James—who does not fail to signalize the mainly negative outcome of Mr. Joachim's essay as, in so far, an argument in his own behalf—presents pragmatism, in eight Lowell lectures, as essentially a mediator, methodologically and metaphysically, between absolute idealism and empiricism. The lectures deal with the present dilemma in philosophy—namely, the antithesis just mentioned; the meaning of pragmatism as method; the pragmatic attitude to some metaphysical problems, such as substance, God, free will, design, the one and the many; the relation of pragmatism to common sense; pragmatism's conception of truth; pragmatism and humanism; pragmatism and religion. The book makes delightful reading; but it does not appear that the fundamental confusion often charged to the account of the pragmatist, the confusion of truth with knowledge of truth, is finally cleared up. And it may be doubted whether the middle position finally recommended will satisfy many temperaments, since a temperament, however mixed its origin and character, generally leans with some bias to the one philosophical side or to the other. To put the matter crudely, Professor James will probably be too religious for the non-religious, and not religious enough for the religiously minded.

P. E. WINTER.

Essay on the Creative Imagination, by T. RIBOT. Translated from the French by A. H. N. Baron. Chicago, Open Court Publishing Co., 1906. pp. xix, 370.

M. Ribot holds an unique position among descriptive psychologists·

Every few years he calls attention, in an elaborate essay, to some field of work—general ideas, affective memory, creative imagination, the passions—that has so far been neglected, whether by the descriptive or by the experimental school. The combination of a strong systematic bent with a high degree of literary skill makes this series of books doubly valuable; they are found readable by the general educated public, and they offer to the psychologist, without pretence of finality, a conspectus of fact and opinion gleaned from scattered sources and arranged on a workable plan. Mr. Baron's translation is, therefore, most welcome; we may safely predict that one of its results will be the carrying of various part-problems of imagination into the laboratories. The translation itself, while by no means sympathetic, appears to be accurate. The proof-reading of the book has been very carelessly done. P. E. WINTER.

Text Book of Psychiatry, a psychological study of insanity, by DR. E. MENDEL. Authorized Translation. Edited and enlarged by Wm. C. Krauss. F. A. Davis, Philadelphia, 1907. pp. 311.

The psychiatrical clinic is now obligatory to medical students in most countries and schools, and in Berlin since 1901 has been a topic on which all doctors must be examined. There are of course very many excellent texts on the subject in German, but the author here tries to present it in a general perspective to enable students to fill up the gaps in the clinic and to reduce all to its proper time and place. The author himself stands in the front rank of German men of science and for thirty years has been a leader in Germany and also distinguished by his hospitality to Americans. The plan of the book represents Mendel's latest views of classification. Under general symptomatology he discusses disturbances of sensation, of thought, memory, feeling, judgment, conscious action, including speech, and has a pregnant chapter on physiological disturbances in the condition of the body, including physical degeneracy, motility, reflections, basal motor nerves and internal organs. Under etiology, a chapter on statistics discusses the factors favoring breaking out of disease, such as puberty, climacteric and old age. Direct causes are classified as psychic, somatic and mixed. Outbreaks may be transitory, acute, or chronic. There are sections on pathological anatomy, diagnosis, prognosis and treatment. Then he discusses special psychiatry, imbecility, idiocy and psychosis, hallucination, mania, melancholia, circular psychosis, acute dementia, psychosis from central neuroses such as epilepsy, hysteria and chorea, with a special section on intoxication. Then follows an account of the psychosis due to thyroid trouble, to poisons from without, to organic and inorganic poisons. Under organic psychosis he discusses diffused diseases of the cortex including progressive paralysis, senile dementia, arterial sclerotic psychosis and apoplexy. The work ends with instructions for examining a person mentally diseased and for rendering an opinion.

Psychology Applied to Medicine, an introductory study, by DAVID W. WELLS. Davis, Philadelphia, 1907. pp. 141.

The author thinks the proposition "*all* disease is mental" seems so absurd to the medically trained man that he is apt to ignore the fact that some disease is mental. He advocates psycho-therapeutics, including hypnotism in special cases. Indeed, this mode of cure began with Edward the Confessor, in the eleventh century, who cured the king's evil. The author repudiates Mrs. Eddy, metaphysical healers and theosophists, agrees with Wetterstrand that there is no better cure for insomnia than hypnosis and that special soporifics are injurious. He believes that sometimes hypnosis helps neuralgia, stam-

mering and the cigarette habit. Physicians like J. J. Putnam who is treating hysteria by Freud's psycho-analytic method, Quackenbos of New York, Dubois of Berne, the author of the very notable "Psychic Treatment of Nervous Disorders," and the general use of placebos, the growing view that drug therapeutics, which requires only the writing of prescriptions as the easiest thing, often leads directly to patent medicines, the patient seeking to avoid the middleman and get the goods direct (the physician being only a middleman for the drug maker): all these show the tendency which this book also exemplifies. The writer believes that the psychic element is present in all therapeutics, in surgery, electro-therapy, massage, that in quack medicines it is often not a drug but this element that cures, and that the same is true to some extent with prescriptions of regular physicians. We must not shut our eyes to the real value of this element because it has been abused by Christian Science.

The Influence of the Mind upon the Body, by PAUL DUBOIS. Translated from the fifth French edition by L. B. Gallatin. Funk & Wagnalls Company, New York, 1906. pp. 63.

The dependence of the soul upon the body commences in the cradle and finishes only with the grave. This volume does not deal with the speculative or the philosophical aspects of the subject, but rather with those that are moral and therapeutic. The object of culture is to subdue the body till it becomes a perfect servant of the soul. Self-control begins in the domination of the body by the soul. There are no imaginary sick people, but all suffer and therefore all are worthy of compassion and in need of cure. Exaggerated emotionalism is one of the most common diseases of modern life and nothing is more contagious than nervous affections. Many of these arise under the influence of real, and others from an imaginary, fatigue. The best cure is in the domain of higher morality, which does have remarkable power to steady the whole personality. We must have some kind of religion and philosophy and live up to it, and our philosophy must include some method or cure of anxiety.

A Treatise on the Motor Apparatus of the Eyes, embracing an exposition of the Anomalies of the Ocular Adjustments and their Treatment, with the Anatomy and Physiology of the Muscles and their Accessories, by GEORGE T. STEVENS, M. D., Ph. D. Philadelphia, F. A. Davis Co., 1906. pp. xiv, 496; 184 illustrations, some in colors and many original.

This work, by one of the leaders among American ophthalmologists, is in reality a sequel to the same author's earlier work on Functional Nervous Diseases, published in 1884, in which was first emphasized the causal connection of motor anomalies of the eyes with many functional nervous troubles. The present work gathers up the results of many papers published in the intervening years in the *Archives of Ophthalmology* and the *Annals d' Oculistique*, and gives them here again in connection with brief statements of current knowledge with reference to the anatomy of the eye muscles and adjacent parts, and with reference to paralytic and obstructive troubles of the same organs.

The work opens with an historical sketch of strabismus and heterophoria. Part I follows with nearly sixty pages upon structural relations, including a section on comparative anatomy. Part II deals in about twice as many pages with the physiology of the eye muscles and their functions. The longest section is Part III, devoted to anomalous conditions of the eye-muscles not dependent upon disease. It is these which are the fruitful source of nervous troubles.

Part IV treats in forty-five pages of conditions depending directly on disease affecting the motor functions, paralysis, spasm, etc.

While items of psychological interest will be found in other sections, it is in the second that the psychologist will come upon familiar captions like "The Visual Perception of Space," "Unconscious Conclusions," "Of Corresponding Points," and "The Horopter." And here he will find a good deal that is the result of fresh and first-hand observation, particularly with reference to physiological questions, but much also of Helmholtzian psychologizing which, by present standards, may be justly described as antique. The section is, however, one which no psychologist dealing with the phenomena of space perception will do well to neglect altogether—in especial a couple of pages of friendly criticism upon recent psychological studies of eye movements in space perception. E. C. S.

Osservazioni cliniche ed anatomiche sulle demenze post-apoplettiche. DOTT. G. MINGAZZINI, Rivista Sperimentale di Freniatria, 1897, Vol. 23, p. 821.

A point worthy of special note is the extreme emotivity of some of the patients which results in spasmodic weeping and laughing. The physio-anatomical reason of such disturbances has been referred by Brussoud to the involvement of some special classes of nerve fibres. According to him, along the anterior segment and the lance of the internal capsule, there run little bundles of cortical fibres, which extend to the centres of co-ordination of the mimetic muscles, situated in the *thalamus*. If a lesion is situated simply in contact with the anterior segment, it would have the effect of irritating the fibres which pass there; if, on the contrary, it involved the segment itself, the effect would be of a paralytic nature; in both cases the cortex would lose the power of regulating the mimetic centres situated in the *thalamus* and these would respond to all peripheral impressions, hence there would arise, sometimes spasmodic laughing, sometimes spasmodic weeping, which the patient would be unable to control.

"I have observed a true case of spasmodic weeping in two patients (Antonini and Valeri) who, whenever they attempted to reply to any question, broke into uncontrollable weeping. Sometimes a stimulus of such a nature, as to be entirely independent of every sad thought was sufficient to induce the weeping. In the first case (Antonini), there existed bilateral lesions of the lenticular nucleus which on the right side was situated near the anterior segment of the internal capsule. In the second patient (Valeri) was found on the left side a lesion of the *putamen* and of the internal membrane of the *globus pallidus*." THEODATE L. SMITH.

Hygiene of Nerves and Mind in Health and Disease. By A. FOREL. Authorized translation from the second German edition by H. A. Aikins. New York, G. P. Putnam's Sons, 1907. pp. x, 343.

M. Forel's work is a compendium of psychology, physiology, pathology and hygiene, dominated and unified by the author's well-known monistic philosophy. It is written with all the reformer's enthusiasm, which carries the reader triumphantly over a mass of details that, otherwise presented, would be dry enough. The defect of this quality is, of course, a one-sidedness that makes the book distinctly irritating to the specialist. There can, however, be no doubt that its general influence will be wholesome.

The translation is very uneven. Alongside of much careful work we find slips of grammar ("a dozen children of the same parents deviate from each other"), disturbing colloquialisms ("precious little can be gotten out of the words Nature and Natural"), uncertain-

ties of terminology ("psychopathias" and "psychopathies"), awkward phrases ("a fish running away at our approach"), etc., etc. There seems, too, to be no clear principle running through the notes added by the translator. If the reader needs to be told that "the word Phenomenon as used in psychology or any other science does not mean something remarkable, but merely something that can be observed" (p. 17), it is surely superfluous to warn him that the Spinoza-Fechner law of identity is "to be distinguished from the logical law with the same name" (p. 78)!

P. E. WINTER.

Morris's Human Anatomy: a complete systematic treatise by English and American authors. Edited by H. Long and J. P. McMurrich. Fourth edition, part iii: The Nervous System; Organs of Special Sense. Philadelphia, P. Blakiston's Son & Co., 1907. pp. x, 747-1113.

The psychologist is more likely to consult a work on physiology or histology than a text-book in anatomy. Nevertheless, anatomy must, at times, be referred to; and on such occasions this present volume of the revised Morris will prove of great assistance. The part deals with the nervous system, eye, ear, tongue and nose. The illustrations are numerous, clear (many of them are partially colored), and well-chosen, and the text is up to date. The section on the nervous system has been corrected and largely rewritten by Professor Hardesty, of the University of California; that on the eye by Dr. Gunn, of the London Ophthalmic Hospital; and that on ear, nose, and tongue by Professor Kerr of the Cornell Medical College. The price, $1.50, is extremely moderate.

H. E. HOTCHKISS.

BOOK NOTES.

Laboratory Manual of Psychology, by CHARLES HUBBARD JUDD. Volume II of a series of text-books designed to introduce the student to the methods and practices of scientific psychology. Charles Scribner's Sons, New York, 1907. pp. 127.

The chapters are on the quantitative study of geometrical optical illusions, characteristics of the different parts of the retinal field, color sensations, monocular visual experiences, binocular visual experiences, binaural recognition of direction, tonal sensations, cutaneous sensations, tactual space perception, sensation intensities, apparatus and methods for recording movements, changes in circulation accompanying changes in consciousness, changes in muscular tension of the voluntary muscles, muscular co-ordination, unnoticed variations in simple co-ordinated movements, voluntary modifications in movement, analysis of voluntary co-ordinations, effects of practice (a) impression factors, effects of practice (b) motor and perceptual habits, distraction and fatigue, memory, fluctuations of attention, scope of attention and consciousness, æsthetic appreciation, experimentation with complex mental processes.

Woman and the Race, by GORDON HART. Ariel Press, Westwood, Mass., 1907. pp. 264.

The themes in this book are: Innocence versus ignorance, flower babies, woman's place in the social scheme, motherhood a joy, real paternity, a perfect body, king mind, the rationale of celibacy, marriage actual and ideal, the joy of life. These very chapter heads suggest to an unusual degree the point of view and even the content

of the book. It is thoroughly well meant and there seems to be nothing bad or objectionable. It might be described as excellent table talk. It makes little claim to be scientific and does not utilize the results of recent literature.

Zeitschrift für Religionspsychologie, Grenzfragen der Theologie und Medezin. Carl Marhold, Halle a. S., 1907, Band I, Heft 4. pp. 145-184.

We regret to observe that Dr. Vorbrodt has withdrawn from the editorship of the *Zeitschrift*. We are glad, however, to note that the editors hope soon to have another theologian in his place. The character of the fourth number is somewhat medical and the chief articles are the psychiatry and the care of the soul in corrective and penal institutions for women, social and individual care of the soul, ethical values under the influence of fatigue, the antipathy of the ancient Jews against pictures and images. The review department is restricted to the discussion of a single article.

L'Égalité, par J. J. ESCAUDE. Bibliothèque Coopérative Laique et Républicaine, Paris, 1907. pp. 73.

This writer discusses the idea of individuality and equality and traces the latter through the historic period, points out the chief traits of genuine equality, its sources, its relations to wealth and its future. The book is interesting and suggestive.

Die Beeinflussung der Sinnesfunktionen durch geringe Alkoholmengen, I Teil, von WILHELM SPECHT. Wilhelm Engelmann, Leipzig, 1907. pp. 115.

Diseases of the Rectum: Their consequences and non-surgical treatment. By W. C. BRINKERHOFF. Orban Publishing Company, Chicago, 1907. pp. 207.

Paranoia, its varieties and medico-legal importance, by CHARLES W. BURR. Reprinted from the Journal of the American Medical Association, June 1, 1907, Vol. 48, pp. 1852-1855. Press of the American Medical Association, Chicago, 1907.

A Case of the Loss of Memory, by CHARLES W. BURR. Reprinted from American Journal of Insanity, Vol. 63, No. 3, January, 1907, pp. 377-383.

NOTE.

Wilhelm Stern has changed his well known *Aussage* to the *Zeitschrift für angewandte Psychologie und psychologische Sammelforschung*, of which the first double number of the first volume, containing 187 pages, is at hand. Although the scope is greatly enlarged and Otto Lipmann becomes joint editor, the new *Zeitschrift* is called a broadened continuation of the old. The first number is very attractive and promising.

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